Ivanpah Valley Airfield Alternative ANalysis (IVAAAN)

Simulation Summary Report

Level 1 and Level X Simulations
February 26 to March 8, 2007

Level Y Simulation
May 21 to May 25, 2007

Revision 2.0

Disclaimer: Due to inherent limitations of virtual reality, decisions should not be based solely on results obtained in FutureFlight Central. This simulation does not address engineering feasibility or adherence to regulatory requirements. NASA shall not be liable for direct, indirect, or consequential damage or injury arising from decisions made based on this data. Although NASA has included capacity data in this report, it is not a precise quantitative assessment of the capacity impact of any airport or airfield.

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1.0 Executive Summary

This report presents the summary of the results of the Ivanpah Valley Airfield Alternative ANalysis (IVAAAN) simulations conducted at the NASA Ames Research Center FutureFlight Central virtual reality air traffic control tower simulator. The simulation provided quantitative operational and subjective data for the proposed Ivanpah Valley Airport. Two airport layouts were considered: a closely-spaced runway configuration and a widely-spaced runway configuration. The simulations modeled three traffic levels:

- Level 1 - low traffic-level scenarios (approximately 30 operations per hour)
- Level X - high traffic-level scenarios at peak arrival and departure rates (approximately 90 operations per hour)
- Level Y – high traffic-level scenarios at peak arrival and continuous, high-demand departures (approximately 110 operations per hour).

Level 1 and Level X simulations were conducted from February 26 to March 8, 2007. After analyzing the results of the Level X simulation, the customer requested a follow-on simulation. The follow-on simulation is called Level Y. The Level Y simulation was conducted from May 21 to May 25, 2007.

In comparing Level 1 simulation data results for the two airport configurations at the low traffic-level, there appear to be some trade-offs. For north-flow operations, *longer* outbound taxi times and *shorter* inbound taxi times were measured for the widely-spaced runway configuration than for the closely-spaced runway configuration. For south-flow operations, however, *shorter* outbound taxi times and *longer* inbound taxi times were measured for the widely-spaced runway configuration than for the closely-spaced configuration.

At the higher traffic-level, Level X, there was a more consistent and larger differential in inbound taxi times: 40% higher for the closely-spaced runway configuration. The calculations for the closely-spaced runway interactions indicate nominally two minutes of delay for arrivals due to runway crossings. Subjective data from the high traffic-level scenarios clearly identified higher workload levels and safety concerns for the closely-spaced runway configuration. The air traffic controller participants rated the widely-spaced runway configuration to be more efficient, easy to manage and safe. The number of radio transmissions on the local controller's frequency was nearly two times higher for the closely-spaced runway configuration, supporting the subjective data. However, there was a small relative difference in the departure rates between the two airfields. Further analysis indicates there was not a continuous departure demand.

For Level Y, with the same arrival rates as in Level X but with an increase departure demand the departure queue was continuously full during the course of the simulation. The most notable difference between the two airfields was the departure rates. The departure rate achieved under the widely-spaced runway configuration was greater by about 15 departures per hour than for the closely-spaced configuration. The average inbound taxi time for the closely-spaced runway configuration was 55% higher than for the widely-spaced configuration. There was nominally 4.5 minutes delay for arrivals due to runway crossings. The subjective data for Level Y were similar to Level X, that is,

high workloads and safety concerns were identified for the closely-spaced runway configuration. With the increased number of the departures for the two airfields, the number of transmissions for the ground controllers increased by 30% in comparison to Level X simulation. The audio data indicate heavy workloads for both the local and ground controllers for the closely-spaced configuration.

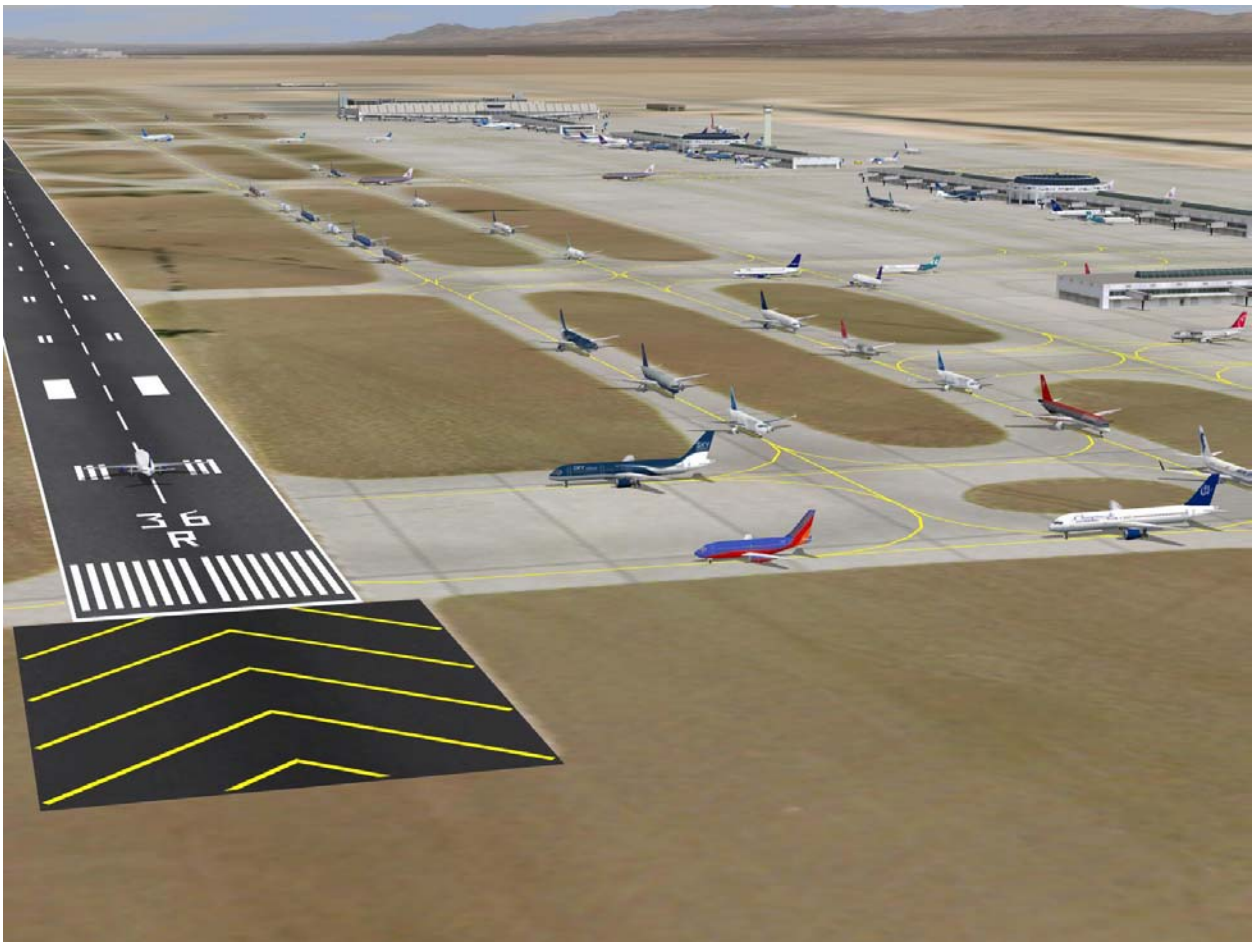

Figure 1: Closely-Spaced Runway Configuration

View of the departure queue simulated in a Level Y scenario

2.0 Introduction

McCarran International Airport (LAS) in Las Vegas, Nevada is the sixth busiest airport in the nation and is expected to reach its capacity of about 55 million passengers a year by 2015. The Clark County Department of Aviations (CCDOA) is planning to build a new full service international airport in the near future in the Ivanpah Valley. The airport site, a 6000-acre dry lakebed, is located 30 miles south of Las Vegas. The proposed airport will help alleviate congestion at LAS, which can no longer expand because of the existing housing and commercial development that surrounds it. The site selection and Airport Layout Plans (ALPs) have been developed and the Federal Aviation Administration (FAA) is preparing an Environmental Impact Statement (EIS) for the facility. The new airport is anticipated to open in the year 2017, initially servicing 6 million passengers per year.

ASRC Research and Technology Solutions (ARTS) evaluated the two ALPs at the FutureFlight Central (FFC) virtual reality air traffic control tower simulator. The real-time, human-in-the-loop simulations with the participations of former FAA air traffic controllers were conducted from February 26 to March 8, 2007 and from May 21 to May 25, 2007. FFC is located at NASA Ames Research Center, Moffett Field, California.

3.0 Simulation Description

FFC developed high fidelity 3D representation of the two ALPs, operating under visual flight rule (VFR) conditions and gathered surface data for each plan to evaluate the relative efficiency and safety of the two plans. The two ALPs are as follows:

1) **West Runway Plan** which the two parallel runways are 1,200 feet apart and located on the west side of the terminal buildings. This plan is also known as the Closely-Spaced Runway Configuration.

2) **Midfield Terminal Plan** in which the terminal buildings and facilities are situated in the midfield in between the two parallel runways that are 4,800 feet apart. This plan is also known as the Widely-Spaced Runway Configuration.

Each proposed ALP considered the operations for three levels of development:

- Opening day (~46,000 operations/year)
- Partial terminal facilities build-out (71 gates, ~184,000 operations/year)
- Full terminal facilities build-out (97 gates, ~368,000 operations/year)

Additional levels of development, in which the airport will have the full terminal facilities build-out, and high-demand traffic flow, were added specifically for the simulation. These higher levels were used to determine which airfield plan could more efficiently accommodate a more continuous and demanding flow of traffic, anticipated well into the future.

The CCDOA chose to model:

- Partial terminal facilities build-out (71 gates, ~184,000 operations/year)
- Full terminal facilities build-out/high traffic (97 gates, ~780,000 operations/year)

- Full terminal facilities build-out/increased departure demand (97 gates, ~950,000 operations/year)

The development levels were identified as Level 1, Level X and Level Y, respectively. The Level 1 simulation included night scenarios for each of the airport layouts. Level 1 scenarios were based on the TAAM (Total Airspace and Airport Modeler) fast-time simulation models provided by Ricondo and Associates for each ALP.

Level X scenarios were developed using the following criteria:

- Arrival rate determined by the minimum allowable aircraft in-trail separation
- 15 miles separation of arrivals for the departure runway
- Peak departure rate, approximately 50 operations/hour

After analyzing the results from Level X simulation, it was determined that there was not a sufficient departure demand. A follow-on simulation was developed and was conducted from May 21 to 25, 2007. The follow-on simulation was called "Level Y".

Level Y scenarios were developed using the following criteria:

- Arrivals rates for two runways are identical to Level X
- Aircraft departure demand increased to ensure a continuous queue of aircraft for the departure runway.

Scenarios for two traffic-flow directions were prepared: north-flow and south-flow. The north-flow traffic used runway 36L for arrivals and runway 36R for the departures. The south-flow traffic used runway 18R for arrivals and runway 18L for departures. A total of sixteen unique scenarios were developed to include the two ALPs, two levels of airport development, day scenes for Level X and Y, day and night scenes for Level 1, and two traffic-flow directions. Table 1 lists the number of arrivals programmed during the 45-minute scenario.

Preprogrammed Arrivals (count)		
Scenario	**West Runway Plan**	**Midfield Terminal Plan**
Level 1 - Day	13	14
Level 1 - Night	16	16
Level X & Level Y	40	40

Table 1: Number of Arrivals

The naming convention for the scenarios is as follows:
<Airport Layout=W or M > <Development/Build-out Level=1, X or Y> <Flow=N or S> <Scene=DAY or NITE>

West Runway Plan Scenarios	
Scenario	Description
W1NDAY	Level 1, North-Flow, Day Scene
W1SDAY	Level 1, South-Flow, Day Scene
W1NNITE	Level 1, North-Flow, Night Scene
W1SNITE	Level 1, South-Flow, Night Scene
WXNDAY	Level X, North-Flow, Day Scene
WXSDAY	Level X, South-Flow, Day Scene
WYNDAY	Level Y, North-Flow, Day Scene
WYSDAY	Level Y, South-Flow, Day Scene

Table 2: West Runway Plan Scenarios

Midfield Terminal Plan Scenarios	
Scenario	Description
M1NDAY	Level 1, North-Flow, Day Scene
M1SDAY	Level 1, South-Flow, Day Scene
M1NNITE	Level 1, North-Flow, Night Scene
M1SNITE	Level 1, South-Flow, Night Scene
MXNDAY	Level X, North-Flow, Day Scene
MXSDAY	Level X, South-Flow, Day Scene
MYNDAY	Level Y, North-Flow, Day Scene
MYSDAY	Level Y, South-Flow, Day Scene

Table 3: Midfield Terminal Plan Scenarios

4.0 Airport Layout

FFC created four airport databases to depict the partial build-out and full build-out (included Terminal C) for both the West Runway Plan and the Midfield Terminal Plan. FFC combined CAD drawings, aerial photos, photos from the perspective of the designated tower location, and conceptual drawings to create a realistic depiction of the two airport plans, and the surrounding terrain and skyline. The buildings were based on the dimensions and facade similar to the newest terminals at LAS. In areas where little or no information was available, FFC created as realistic of a representation as possible. Runway and taxiway lights, aircraft lights and lighting of the airport buildings and ramp areas provided realistic night scenes.

5.0 Traffic Flow

A proposed gate diagram and eight taxiway diagrams were provided by ARTS. The eight taxiway diagrams depicted the traffic flow for the two ALPs, two build-out levels, and two flow directions. FFC modified the gate assignments for Terminal A to be consistent

with Terminal B and C. FFC also modified some of the taxiway names so that the taxiways surrounding the runways were consistent for the two ALPs (see Appendix F). Taxiways B and C were the primary taxiways just west of the ramp area. Taxiway A was the parallel taxiway in between the runways for the West Runway Plan, thus it did not exist in the Midfield Terminal Plan. Ten spots were added to the West Runway Layout and 21 spots were added to the Midfield Terminal Layout. In the ramp area, parallel taxi-lanes surrounded the terminals. The inner taxi-lanes were used for departures and the outer taxi-lanes were used for arrivals.

For north-flow operations, the south side of the parallel taxi-lanes, in between the terminals, was used by outbound traffic. Outbound flights used the odd numbered spots, except for spots 8 and 9 for both plans. In this case, spot 8 was used for departing flights and spot 9 was used for arriving flights. During south-flow operations, the taxi-lanes usage was reversed. The north side of the parallel taxi-lanes, in between terminals, was used for the outbound traffic. The outbound flights used the even numbered spots.

The traffic flow maps in Appendix F do not describe all possible traffic flows. For instance, during the Midfield Terminal Plan, Level X runs, the arrivals landed on both runways, on opposite sides of the airfield. As these arrivals proceeded to their gates, the ground controllers had to direct some aircraft to use the departure's taxi-lanes to avoid head-on situation.

6.0 Run Schedule

The Level 1 and Level X training and simulation was conducted over a period of nine days. The Level Y training and simulation was conducted over a period of five days. Two 45-minute runs for each of the scenarios were used for comparison and to calculate the averages. Runs that are in gray text were repeated and not included in the average calculation. The controllers rotated positions during the simulation to avoid familiarity with any particular scenario.

Anomalies were discovered for runs 22 and 28. These runs were for the West Runway Plan, Level X scenarios. Each of these runs had a single flight that took more than 100 seconds to cross the inboard runway. Typically, the runway crossing duration ranged from 25 to 50 seconds. Flight NWA1855 was removed from run 22 and flight UAL2593 was removed from run 28. These flights were not included in the statistical calculations.

Date	Run	Scenario	Tower Config.	Comments
Level 1				
Feb. 26		Training		
Feb. 27	1	W1NDAY	2 Controllers	Initial run.
	2	W1NNITE	2 Controllers	Initial run
	3	M1NDAY	2 Controllers	Initial run
	4	M1NNITE	2 Controllers	Initial run
	5	W1NDAY	2 Controllers	Repeat run
	6	W1NDAY	2 Controllers	Repeat run. Replaced Run 5.
Feb. 28	7	W1NNITE	2 Controllers	Repeat run
	8	M1NDAY	2 Controllers	Repeat run
	9	M1NNITE	2 Controllers	Repeat run
	10	W1NDAY	2 Controllers	Initial run. Replaced Run 1
March 1	11	W1SDAY	2 Controllers	Initial run
	12	W1SNITE	2 Controllers	Initial run
	13	M1SDAY	2 Controllers	Initial run
	14	M1SNITE	2 Controllers	Initial run
	15	M1NDAY	2 Controllers	Initial run Replaced Run 3.
March 2	16	W1SDAY	2 Controllers	Repeat run
	17	W1SNITE	2 Controllers	Repeat run
	18	M1SDAY	2 Controllers	Repeat run
	19	M1SNITE	2 Controllers	Repeat run
Level X				
March 5		Training		
March 6		Training		
March 7	20	MXNDAY	4 Controllers	Initial run
	21	WXNDAY	2 Controllers	Initial run.
	22	WXNDAY	2 Controllers	Initial run. Replaced Run 21.
	23	WXNDAY	2 Controllers	Repeat run
	24	MXNDAY	4 Controllers	Repeat run
	25	MXSDAY	4 Controllers	Initial run
March 8	26	WXSDAY	2 Controllers	Initial run.
	27	MXSDAY	4 Controllers	Repeat run
	28	WXSDAY	2 Controllers	Repeat run.
	29	MXSDAY	4 Controllers	Repeat run. Replaced Run 27.
	30	WXSDAY	2 Controllers	Initial run. Replaced Run 26.

Table 4: Run Log – Level 1 and Level X

Date	Run	Scenario	Tower Config.	Comments
Level Y				
May 21		Training		
May 22		Training		
May 23		Training		
May 24	31	WYNDAY	2 Controllers	Initial run
	32	WYNDAY	2 Controllers	Repeat run.
	33	MYNDAY	4 Controllers	Initial run.
	34	MYNDAY	4 Controllers	Repeat run. .
	35	MYSDAY	4 Controllers	Initial run.
	36	MYNDAY	4 Controllers	Repeat run. Replaced Run 34.
May 25	37	MYSDAY	4 Controllers	Repeat run.
	38	WYSDAY	2 Controllers	Initial run
	39	WYSDAY	2 Controllers	Repeat run.

Note: Blue indicates north-flow scenarios and green indicates south-flow scenarios.

Table 5: Run Log – Level Y

7.0 Simulation Participants

Former FAA air traffic controllers participated in the simulation. Two controllers (one Local, one Ground) were used for all of the Level 1 scenarios and for the Level X and Y, West Runway Plan scenarios. Four controllers were used for the Midfield Terminal Plan, Level X and Y scenarios because the tower is situated between the parallel runways (see Figure D2). Two controllers were required on each side to manage the higher traffic volume. The tower positions of the controllers are shown in Appendix D. In addition to the controllers, a clearance delivery position was included for all of the Level 1 scenarios and Level X and Y, Midfield Terminal Plan scenarios. A local assist and ground assist were used for the Level X and Y, West Runway Plan scenarios.

Sim-pilots (simulation pilots) were hired to move the aircraft in the scenarios using a graphical user interface and to provide radio communication. Four sim-pilots participated in the Level 1 simulation, and eight sim-pilots in participated the Level X simulation. Due to the increase in the departure demands in Level Y, ten sim-pilots participated in this simulation.

7.1 Data Collected

Two repetitions of each scenario were made. The data collected included air traffic controller surveys, digital audio communication and airport surface statistics.

7.2 Air Traffic Controller Surveys

There were five surveys administered. Samples of the surveys are provided in **Appendix A**.

- IVAAAN Confidential Controller Survey ATC Post-Run Questionnaire (Level 1 and X)
- IVAAAN Confidential Controller Survey Airfield Comparison (Level 1)
- IVAAAN Confidential Controller Survey Airfield Comparison (Level X)
- IVAAAN Confidential Controller Survey ATC Post-Run Questionnaire (Level Y)
- IVAAAN Confidential Controller Survey Airfield Comparison (Level Y)

After each run, participating controllers filled out the ATC Post-Run Questionnaire, rating various aspects of the operation. At the completion of all runs for each level, all of the participating controllers filled out the appropriate Airfield Comparison survey to select and rate the ALP alternatives with respect to various measures efficiency and safety.

In the Airfield Comparison Survey, the controllers selected their preferred airfield or "no difference" to 16 questions with regards to ease of managing aircraft, situational awareness of the airfield, efficiency and safety. Table 6 summarizes the comparison of alternatives across all questions.

Comparison Survey Results				
	No. of Controllers	West Runway Plan	Midfield Terminal Plan	No Difference
Level 1	3	19%	56%	25%
Level X	5	1%	91%	8%
Level Y	4	2%	92%	6%

Table 6: Controllers' Airfield Preference

All completed surveys were delivered to ARTS separately.

The results from all of the runs and the averages of the results are provided in Appendix B and Appendix C.

7.3 Digital Audio Communication

All controllers and pilot transmissions were recorded for all runs and archived.

The tables below describe the communication setup used during the simulation:

Controller Station	Acronym	Radio Frequency
Ground Controller	GC	121.2
Local Controller	LC	117.7

Table 7: Radio Frequencies for West Runway Plan, Levels 1, X & Y and for Midfield Terminal Plan, Level 1

Controller Station	Acronym	Radio Frequency
Ground Controller East	GCE	121.8
Local Controller East	LCE	117.7
Ground Controller West	GCW	121.2
Local Controller West	LCW	117.7

Table 8: Radio Frequencies for Midfield Terminal Plan, Level X & Y

7.4 Airport Surface Statistical Data

The FFC simulation system records discrete events for each aircraft on the surface of the airport. From these events, the following are calculated:

Arrival Statistics	Departure Statistics
Total Touchdown Count	Total Movement Area Pushbacks
Total Runway Exit Count	Total Non-Movement Area Pushbacks
Average Runway Occupancy Duration	Total Pushbacks Count
Average Inbound Taxi Duration*	Total Takeoff Count
Total Number of Inbound stops	Avg. Outbound Taxi Duration*
Total Inbound Stop Duration	Avg. Runway Occupancy Duration
Average Inbound Stop Duration*	Total Outbound Stops
Average Arrival Rate	Total Outbound Stop Duration
Runway Arrival Rates	Average Outbound Stop Duration*
	Average Departure Rate
	Runway Departure Rates

* The inbound taxi duration is the duration for each arrival from the touchdown point to the gate. The outbound duration is the duration from the moment the pushback command is executed to the time when departure flight takes off.

Table 9: Airport Surface Data Summary

Runway crossing data were calculated for the West Runway Plan scenarios only:

- *Duration Held for Crossing* for each arrival held at the hold-short point of the runway.
- *Runway Crossing Duration* for each arrival from the hold-short point to the point on the other of side of the runway.
- *Runway Unavailable Duration* is the crossing duration for a single arrival or the accumulated crossing time of multiple arrivals crossing the runway between departures. The accumulated time is measured from the start time of the first arrival crossing the runway to the ending time of the last arrival crossing the runway.

7.4.1 Airport Surface Statistics

The complete Airport Surface Statistical data report in text format will be provided separately from this document.

7.4.1.1 Airport Surface Key Results

This section summarizes the key results.

Key Airport Statistics - Level 1			
		West Runway Plan	**Midfield Terminal Plan**
North-Flow			
Avg. Inbound Taxi Duration (sec.)	Day	348.0	247.4
Avg. Inbound Taxi Duration (sec.)	Night	353.8	253.8
Avg. # of Dep. From Gate to Takeoff	Day	10	10
Avg. # of Dep. From Gate to Takeoff	Night	4	4
Avg. Outbound Taxi Duration (sec.)	Day	494.6	570.6
Avg. Outbound Taxi Duration (sec.)	Night	501.8	540.9
Airport Departure Rate (ops./hr.)	Day	14.6	16.0
Airport Departure Rate (ops./hr.)	Night	6.7	6.6
South-Flow			
Avg. Inbound Taxi Duration (sec.)	Day	310.3	336.3
Avg. Inbound Taxi Duration (sec.)	Night	311.2	327.1
Avg. # of Dep. From Gate to Takeoff	Day	10	10.5
Avg. # of Dep. From Gate to Takeoff	Night	4	4
Avg. Outbound Taxi Duration (sec.)	Day	590.3	522.1
Avg. Outbound Taxi Duration (sec.)	Night	598.9	548.5
Airport Departure Rate (ops./hr.)	Day	14.6	15.0
Airport Departure Rate (ops./hr.)	Night	8.0	7.9

Table 10: Key Airport Statistics – Level 1

Key Airport Statistics – Level X		
	West Runway Plan	**Midfield Terminal Plan**
North Flow		
Avg. Inbound Taxi Duration (sec.)	509.1	308.0
Avg. # of Dep. From Gate to Takeoff	27	29
Avg. Outbound Taxi Duration (sec.)	910.8	850.8
Airport Departure Rate (ops./hr.)	47.6	48.9
South Flow		
Avg. Inbound Taxi Duration (sec.)	553.1	316.4
Avg. # of Dep. From Gate to Takeoff	27	28.5
Avg. Outbound Taxi Duration (sec.)	950.1	926.7
Airport Departure Rate (ops./hr.)	46.1	48.0

Table 11: Key Airport Statistics – Level X

Key Airport Statistics – Level Y		
	West Runway Plan	**Midfield Terminal Plan**
North Flow		
Avg. Inbound Taxi Duration (sec.)	751.7	326.1
Avg. # of Dep. From Gate to Takeoff	15	25
Avg. Outbound Taxi Duration (sec.)	1650.0	1356.7
Airport Departure Rate (ops./hr.)	50.4	63.5
South Flow		
Avg. Inbound Taxi Duration (sec.)	766.5	347.4
Avg. # of Dep. From Gate to Takeoff	12.5	25.5
Avg. Outbound Taxi Duration (sec.)	1666.5	1401.6
Airport Departure Rate (ops./hr.)	47.0	64.3

Table 12: Key Airport Statistics – Level Y

7.4.1.2 West Runway Plan – Runway Crossing Statistics

West Runway Plan, Runway Crossing Statistics sorted by Taxiways - Level 1				
		No. of Runway Crossings	**Avg. Duration Held for Crossing (seconds)**	**Avg. Runway Crossing Duration (seconds)**
North-Flow				
Taxiway F	Day	5	0.0	32.4
Taxiway F	Night	4	14.8	36.3
Taxiway H	Day	10	9.5	33.7
Taxiway H	Night	27	0.0	31.6
Taxiway K	Day	3	3.0	19.4
Taxiway K	Night	1	0.0	19.0
Taxiway M	Day	3	0.0	26.3
Taxiway M	Night	0	n/a	n/a
South-Flow				
Taxiway H	Day	0	n/a	n/a
Taxiway H	Night	3	0.0	26.0
Taxiway K	Day	20	0.0	17.2
Taxiway K	Night	13	1.5	19.3
Taxiway M	Day	6	8.8	26.5
Taxiway M	Night	3	7.3	29.7

Table 13: Runway Crossing Statistics sorted by Taxiways – Level 1

West Runway Plan, Runway Crossing Statistics sorted by Taxiway - Level X			
	No. Crossings	**Avg. Duration Held for Crossing (seconds)**	**Avg. Runway Crossing Duration (seconds)**
North-Flow			
Taxiway E	1	140.0	34.0
Taxiway F	20	126.3	34.3
Taxiway H	24	94.8	43.2
Taxiway K	13	65.0	26.5
South-Flow			
Taxiway H	5	32.8	33.4
Taxiway K	16	119.9	26.3
Taxiway M	18	140.7	37.1
Taxiway Q	16	163.3	36.9

Table 14: Runway Crossing Statistics sorted by Taxiways – Level X

West Runway Plan, Runway Crossing Statistics sorted by Taxiway – Level Y			
	No. Crossings	**Avg. Duration Held for Crossing (seconds)**	**Avg. Runway Crossing Duration (seconds)**
North-Flow			
Taxiway E	13	272.2	31.9
Taxiway F	10	269.1	37.0
Taxiway H	13	217.6	31.5
Taxiway K	9	373.6	24.2
Taxiway M	2	205.0	32.5
South-Flow			
Taxiway H	13	365.4	38.7
Taxiway K	12	138.6	24.5
Taxiway M	15	247.1	30.2
Taxiway Q	17	435.2	28.6

Table 15: Runway Crossing Statistics sorted by Taxiways – Level Y

West Runway Plan – Runway Crossing Statistics Summary			
	Avg. Total Crossing Duration (seconds)	**Avg. Percent of Total Crossing Duration**	**Avg. Runway Unavailable Duration (seconds/crossing)**
North-Flow			
Level 1, Day	326.0	12.1%	32.0
Level 1, Night	479.5	17.7%	34.2
Level X	677.0	24.9%	56.4
Level Y	321.0	11.8 %	108.2
South-Flow			
Level 1, Day	234.5	8.7%	19.3
Level 1, Night	297.5	11.0%	25.3
Level X	451.5	16.5%	49.2
Level Y	316.5	11.7 %	113.3

Table 16: Summary of Runway Crossing Statistics

Appendix A: Sample Controller Surveys

Ivanpah Valley Airfield Alternative Analysis (IVAAAN)
Confidential Controller Survey
ATC Post-Run Questionnaire

Date:_____

Scenario/Positions Worked (circle all that apply) : Level I : LC GC
Level X: LCE GCE LCW GCW

Airfield Layout Closely Spaced Widely Spaced

Flow Direction (circle one): North South

Time (Circle one): Day Night

Run Number _____

Instructions:
Please answer the following questions based upon your experience in the position you just worked. Your identity will remain anonymous.

1. Rate the airfield on how easy it was to move aircraft "to and from the runways to and from the terminal" during this run.	Extremely Difficult	①②③④⑤⑥⑦⑧	Extremely Easy
2. Rate the airfield on how easy it was to manage aircraft exiting the runway environment.	Extremely Difficult	①②③④⑤⑥⑦⑧	Extremely Easy
3. Rate the airfield on how easy it was to manage the departure queue.	Extremely Difficult	①②③④⑤⑥⑦⑧	Extremely Easy
4. Rate the potential for avoiding runway incursions.	Extremely Poor	①②③④⑤⑥⑦⑧	Extremely Good
5. Rate the airfield on how it affected your overall level of situational awareness during this run.	Extremely Low	①②③④⑤⑥⑦⑧	Extremely High
6. Rate the level of situational awareness provided by this airfield for current aircraft locations during this run.	Extremely Low	①②③④⑤⑥⑦⑧	Extremely High
7. Rate the level of situational awareness provided by this airfield for projected aircraft locations during this run.	Extremely Low	①②③④⑤⑥⑦⑧	Extremely High
8. Rate the airfield based on your ability to visually scan your area of responsibility.	Extremely Poor	①②③④⑤⑥⑦⑧	Extremely Good

10. Rate the airfield on how it affected your scanning workload level.	Very Little	①②③④⑤⑥⑦⑧	A Great Deal
11. Rate the difficulty of this run.	Extremely Difficult	①②③④⑤⑥⑦⑧	Extremely Easy
12. What was the level of traffic complexity under your control during this run?	Extremely Low	①②③④⑤⑥⑦⑧	Extremely High
13. How would you rate the overall level of efficiency of this operation?	Extremely Low	①②③④⑤⑥⑦⑧	Extremely High
14. Rate the performance of the pilots in terms of their responding to your control instructions, providing readbacks, etc.	Extremely Poor	①②③④⑤⑥⑦⑧	Extremely Good
15. Rate the airfield on how it affected your ability of completing necessary transmissions with aircraft.	Extremely Poor	①②③④⑤⑥⑦⑧	Extremely Good

16. What are the most critical problems with this scenario?

17. Is there anything about the study that we should have asked or that you would like to comment about?

End of Survey

Ivanpah Valley Airfield Alternative Analysis (IVAAAN)
Confidential Controller Survey
Airfield Comparison

Date:_____

Scenario/Positions Worked (circle all that apply): Level I: LC GC

Flow Direction Worked (circle all that apply): North South

Times Worked (Circle all that apply): Day Night

Instructions:
Please answer the following questions based upon your total experience with all runs for this traffic level. Your identity will remain anonymous.

1. Which airfield alternative provides the best environment for aircraft movements "to and from the runways to and from the terminal"?	Closely Spaced	Widely Spaced	No Difference
2. Which airfield alternative provides controllers the best environment for managing aircraft exiting the runway environment?	Closely Spaced	Widely Spaced	No Difference
3. Which airfield alternative provides controllers the best environment of managing departure queues?	Closely Spaced	Widely Spaced	No Difference
4. Which airfield alternative provides the best environment for avoiding runway incursions?	Closely Spaced	Widely Spaced	No Difference
5. Which airfield alternative provides the best environment for overall situational awareness?	Closely Spaced	Widely Spaced	No Difference
6. Which airfield alternative provides the best environment for situational awareness for current aircraft locations?	Closely Spaced	Widely Spaced	No Difference
7. Which airfield alternative provides the best environment for situational awareness for projected aircraft locations?	Closely Spaced	Widely Spaced	No Difference
8. Which airfield alternative provides the best environment to visually scan your area of responsibility?	Closely Spaced	Widely Spaced	No Difference
9. Which airfield alternative provides the best environment with regards to your scanning workload level?	Closely Spaced	Widely Spaced	No Difference

10. Which airfield alternative is less difficult to operate?	Closely Spaced	Widely Spaced	No Difference

11. Which airfield alternative is less complex to operate?	Closely Spaced	Widely Spaced	No Difference

12. Which alternative provides the best overall level of efficiency for managing aircraft?	West Runway	Widely Spaced	No Difference

13. In which airfield alternative was the performance of the pilots in terms of their responding to your control instructions, providing read-backs, etc. the best?	West Runway	Widely Spaced	No Difference

14. Which alternative provides the best environment for completing necessary transmissions with aircraft?	West Runway	Widely Spaced	No Difference

15. Which alternative provides the best environment for safety?	West Runway	Widely Spaced	No Difference

16. Which airfield alternative requires the least amount of coordination with the other controllers?	West Runway	Widely Spaced	No Difference

17. Based on your experience, which airfield configuration is preferable? Why?

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18. Do you have any comments or suggestions regarding the airfield alternatives studied?

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19. Is there anything about the study that we should have asked or that you would like to comment about?

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General Simulation Questions

20. Rate the realism of the overall simulation experience compared to actual ATC operations.	Extremely Unrealistic	①②③④⑤⑥⑦⑧	Extremely Realistic
21. Rate the realism of the simulation hardware compared to actual equipment.	Extremely Unrealistic	①②③④⑤⑥⑦⑧	Extremely Realistic
22. Rate the realism of the simulation software compared to actual functionality.	Extremely Unrealistic	①②③④⑤⑥⑦⑧	Extremely Realistic
23. Rate the realism of the simulation traffic runs compared to actual NAS traffic.	Extremely Unrealistic	①②③④⑤⑥⑦⑧	Extremely Realistic

24. Do you have any comments or suggestions for improvement about our simulation capability?

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End of Survey

Ivanpah Valley Airfield Alternative Analysis (IVAAAN)
Confidential Controller Survey
Airfield Comparison

Date:_____

Scenario/Positions Worked (circle all that apply): Level X: LCE GCE LCW GCW

Flow Direction Worked (circle all that apply): North South

ıstructions:
lease answer the following questions based upon your total experience with all runs for this traffic level.
our identity will remain anonymous.

1. Which airfield alternative provides the best environment for aircraft movements "to and from the runways to and from the terminal"?	Closely Spaced	Widely Spaced	No Difference
2. Which airfield alternative provides controllers the best environment for managing aircraft exiting the runway environment?	Closely Spaced	Widely Spaced	No Difference
3. Which airfield alternative provides controllers the best environment of managing departure queues?	Closely Spaced	Widely Spaced	No Difference
4. Which airfield alternative provides the best environment for avoiding runway incursions?	Closely Spaced	Widely Spaced	No Difference
5. Which airfield alternative provides the best environment for overall situational awareness?	Closely Spaced	Widely Spaced	No Difference
6. Which airfield alternative provides the best environment for situational awareness for current aircraft locations?	Closely Spaced	Widely Spaced	No Difference
7. Which airfield alternative provides the best environment for situational awareness for projected aircraft locations?	Closely Spaced	Widely Spaced	No Difference
8. Which airfield alternative provides the best environment to visually scan your area of responsibility?	Closely Spaced	Widely Spaced	No Difference
9. Which airfield alternative provides the best environment with regards to your scanning workload level?	Closely Spaced	Widely Spaced	No Difference

10. Which airfield alternative is less difficult to operate?	Closely Spaced	Widely Spaced	No Difference

11. Which airfield alternative is less complex to operate?	Closely Spaced	Widely Spaced	No Difference

12. Which airfield alternative provides the best overall level of efficiency for managing aircraft?	West Runway	Widely Spaced	No Difference

13. In which airfield alternative was the performance of the pilots in terms of their responding to your control instructions, providing read-backs, etc. the best?	West Runway	Widely Spaced	No Difference

14. Which airfield alternative provides the best environment for completing necessary transmissions with aircraft?	West Runway	Widely Spaced	No Difference

15. Which airfield alternative provides the best environment for safety?	West Runway	Widely Spaced	No Difference

16. Which airfield alternative requires the least amount of coordination with the other controllers?	West Runway	Widely Spaced	No Difference

17. Based on your experience, which airfield configuration is preferable? Why?

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18. Do you have any comments or suggestions regarding the airfield alternatives studied?

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19. Is there anything about the study that we should have asked or that you would like to comment about?

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General Simulation Questions

20. Rate the realism of the overall simulation experience compared to actual ATC operations.	Extremely Unrealistic	①②③④⑤⑥⑦⑧	Extremely Realistic
21. Rate the realism of the simulation hardware compared to actual equipment.	Extremely Unrealistic	①②③④⑤⑥⑦⑧	Extremely Realistic
22. Rate the realism of the simulation software compared to actual functionality.	Extremely Unrealistic	①②③④⑤⑥⑦⑧	Extremely Realistic
23. Rate the realism of the simulation traffic runs compared to actual NAS traffic.	Extremely Unrealistic	①②③④⑤⑥⑦⑧	Extremely Realistic

24. Do you have any comments or suggestions for improvement about our simulation capability?

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End of Survey

Ivanpah Valley Airfield Alternative Analysis (IVAAAN)
Confidential Controller Survey
ATC Post-Run Questionnaire

Date:_____

Scenario/Positions Worked (circle all that apply) : Level Y: LCE GCE LCW GCW

Runway Configuration Closely-Spaced Widely-Spaced

Flow Direction (circle one): North South

Time (Circle one): Day Night

Run Number _____

Instructions:
Please answer the following questions based upon your experience in the position you just worked. Your identity will remain anonymous.

1. Rate the airfield design on how easy it was to move aircraft "to and from the runways to and from the terminal" during this run.	Extremely Difficult	①②③④⑤⑥⑦⑧	Extremely Easy
2. Rate the airfield on how easy it was to manage aircraft exiting the runway environment.	Extremely Difficult	①②③④⑤⑥⑦⑧	Extremely Easy
3. Rate the airfield on how easy it was to manage the departure queue.	Extremely Difficult	①②③④⑤⑥⑦⑧	Extremely Easy
4. Rate the potential for avoiding runway incursions.	Extremely Poor	①②③④⑤⑥⑦⑧	Extremely Good
5. Rate the airfield on how it impacted your overall level of situational awareness during this run.	Negative impact	①②③④⑤⑥⑦⑧	Positive impact
6. Rate the level of situational awareness provided by this airfield for current aircraft locations during this run.	Extremely Low	①②③④⑤⑥⑦⑧	Extremely High
7. Rate the level of situational awareness provided by this airfield for projected aircraft locations during this run.	Extremely Low	①②③④⑤⑥⑦⑧	Extremely High
8. Rate the airfield based on your ability to visually scan your area of responsibility.	Extremely Poor	①②③④⑤⑥⑦⑧	Extremely Good

10. Rate the airfield on how it impacted your scanning workload level.	Negative impact	①②③④⑤⑥⑦⑧	Positive impact

11. Rate the difficulty of this run.	Extremely Difficult	①②③④⑤⑥⑦⑧	Extremely Easy

12. What was the level of traffic complexity under your control during this run?	Extremely Low	①②③④⑤⑥⑦⑧	Extremely High

13. How would you rate the overall level of efficiency of this operation?	Extremely Low	①②③④⑤⑥⑦⑧	Extremely High

14. Rate the performance of the pilots in terms of their responding to your control instructions, providing readbacks, etc.	Extremely Poor	①②③④⑤⑥⑦⑧	Extremely Good

15. Rate the airfield design on how it affected your ability of completing necessary transmissions with aircraft.	Extremely Poor	①②③④⑤⑥⑦⑧	Extremely Good

16. What are the most critical problems with this scenario?

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17. Is there anything about the study that we should have asked or that you would like to comment about?

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End of Survey

Ivanpah Valley Airfield Alternative Analysis (IVAAAN)
Confidential Controller Survey
Airfield Comparison

Date:_____

Scenario/Positions Worked (circle all that apply): Level Y: LCE GCE LCW GCW

Flow Direction (circle all that apply): North South

Time (Circle all that apply): Day Night

Instructions:
Please answer the following questions based upon your total experience with all runs for this traffic level. Your identity will remain anonymous.

1. Which airfield alternative provides the best environment for aircraft movements "to and from the runways to and from the terminal"?	Closely Spaced	Widely Spaced	No Difference
2. Which airfield alternative provides controllers the best environment for managing aircraft exiting the runway environment?	Closely Spaced	Widely Spaced	No Difference
3. Which airfield alternative provides controllers the best environment for managing departure queues?	Closely Spaced	Widely Spaced	No Difference
4. Which airfield alternative provides the best environment for avoiding runway incursions?	Closely Spaced	Widely Spaced	No Difference
5. Which airfield alternative provides the best environment for overall situational awareness?	Closely Spaced	Widely Spaced	No Difference
6. Which airfield alternative provides the best environment for situational awareness of current aircraft locations?	Closely Spaced	Widely Spaced	No Difference
7. Which airfield alternative provides the best environment for situational awareness of projected aircraft locations?	Closely Spaced	Widely Spaced	No Difference
8. Which airfield alternative provides the best environment to visually scan your area of responsibility?	Closely Spaced	Widely Spaced	No Difference
9. Which airfield alternative provides the best environment with regard to your scanning workload level?	Closely Spaced	Widely Spaced	No Difference

10. Which airfield alternative is less difficult to operate?	Closely Spaced	Widely Spaced	No Difference
11. Which airfield alternative is less complex to operate?	Closely Spaced	Widely Spaced	No Difference
12. Which airfield alternative provides the best overall level of efficiency for managing aircraft?	Closely Spaced	Widely Spaced	No Difference
13. In which airfield alternative was the performance of the pilots in terms of their responding to your control instructions, providing readbacks, etc. the best?	Closely Spaced	Widely Spaced	No Difference
14. Which airfield alternative provides the best environment for completing necessary transmissions with aircraft?	Closely Spaced	Widely Spaced	No Difference
15. Which airfield alternative provides the best environment for safety?	Closely Spaced	Widely Spaced	No Difference
16. Which airfield alternative requires the least amount of coordination with the other controllers?	Closely Spaced	Widely Spaced	No Difference

17. Based on your experience, which airfield configuration is preferable? Why?

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18. Do you have any comments or suggestions regarding the airfield alternatives studied?

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19. Is there anything about the study that we should have asked or that you would like to comment about?

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General Simulation Questions

20. Rate the realism of the overall simulation experience compared to actual ATC operations.	Extremely Unrealistic	①②③④⑤⑥⑦⑧	Extremely Realistic
21. Rate the realism of the simulation hardware compared to actual equipment.	Extremely Unrealistic	①②③④⑤⑥⑦⑧	Extremely Realistic
22. Rate the realism of the simulation software compared to actual functionality.	Extremely Unrealistic	①②③④⑤⑥⑦⑧	Extremely Realistic
23. Rate the realism of the simulation traffic runs compared to actual NAS traffic.	Extremely Unrealistic	①②③④⑤⑥⑦⑧	Extremely Realistic

24. Do you have any comments or suggestions for improvement about our simulation capability?

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End of Survey

Appendix B: Results of Controllers Surveys

The following survey results include all survey data from all runs collected during the simulation. The controllers are identified by letters A to E for Level 1 and Level X. A different group of controllers participated in Level Y. Those four controllers were identified as F to I. The ratings were scored from 1 to 8. A high score does not consistently represent a favorable rating for all questions. Each question must be reviewed and evaluated individually to derive the correct conclusion.

Note 1: During the Level 1 simulation, the interpretations of the rating scale for question 5 of the "ATC Post-Run Questionnaire" differed among the controllers. Before the Level X simulation, the value range for question 5 rating was modified as follows: "Negative" replaced "Extremely Low" and "Positive" replaced "Extremely High".

Note 2: The rating values for question 10 of the "ATC Post-Run Questionnaire" may not reflect the desired interpretation of the question. Some controllers may have focused on "scanning workload level" instead of "how the airfield affected your scanning workload level". The range for question 10 is "Very Little" to "A Great Deal". If a controller felt the scanning workload level was low, he may have chosen "Very Little" to indicate the scanning workload level. However, if the airfield configuration had affected his scanning workload level, the same controller should have chosen "A Great Deal" to indicate the airfield configuration was important and had "A Great Deal" affect on the scanning workload level, even if his workload was low for this run.

Note 3: The ratings for questions 5 and 10 were modified for the post-run questionnaire for Level Y. The ratings for question 5 and 10 were changed to "Negative Impact" and "Positive Impact".

Post-Run Survey Results – West Runway Plan

West Runways Plan – Question Ratings																
Run	**Pos.**	**ID**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**	**Q15**
Level 1																
1	LC	A	8	8	8	6	6	7	7	8	7	8	2	6	8	8
	GC	B	8	8	8	8	8	8	8	6	6	8	1	6	8	8
2	LC	B	8	8	8	8	8	7	7	6	3	8	1	6	8	8
	GC	C	8	8	8	8	8	8	8	6	8	8	1	8	6	7
6	LC	C	6	6	8	6	3	3	6	8	1	8	2	6	8	8
	GC	B	7	6	7	7	2	7	6	6	6	8	1	7	7	7
7	LC	A	8	8	8	6	6	6	7	7	6	8	3	7	8	8
	GC	C	8	8	8	7	2	8	8	7	2	8	2	7	6	8
10	LC	B	7	6	6	6	6	7	7	7	3	8	1	6	8	7
	GC	A	7	8	7	7	7	7	7	7	5	7	3	7	8	8
11	LC	C	8	8	8	7	8	8	8	8	2	8	2	8	8	8
	GC	A	7	8	7	6	6	6	6	7	6	7	3	5	8	7
12	LC	A	7	7	8	6	7	6	6	6	6	7	3	5	8	7
	GC	B	7	7	7	6	2	6	6	8	8	1	1	7	8	8
16	LC	A	7	7	7	7	3	7	6	8	2	8	2	7	8	8
	GC	C	8	8	8	6	8	8	8	8	2	8	3	6	7	8
17	LC	B	7	6	7	6	7	6	6	7	4	8	1	7	8	7
	GC	A	7	7	7	6	2	6	6	7	2	8	2	6	8	8
Level X																
22	LC	D		6	6	3	6	6	6	6	5	4	7	6	6	6
	GC	A	3	6	4	5	6	6	6	6	5	5	6	3	8	6
23	LC	E	2	2	2	1	3	6	6	6	2	1	8	1	3	1
	GC	B	7	7	6	5,6*	6	7	7	7	5	6	7	6	7	7
26	LC	C	3	3	5	2	6	5	6	8	8	2	7	2	7	6
	GC	E	2	3	4	1	6	5	4	6	5	3	5	1	5	5
28	LC	E	3	3	3	1	4	4	3	4	5	3	6	1	6	5
	GC	B	4	6	6	4	6	6	7	7	3	3	7	5	5	7
30	LC	E	3	3	3	1	4	4	3	4	5	3	6	1	6	5
	GC	B	4	6	6	4	6	6	7	7	3	3	7	5	5	7
Level Y																
31	LC	F	3	7	8	5	6	6	7	7	6	4	6	4	6	6
	GC	G	3	6	3	1	6	5	5	7	6	3	4	3	5	4
32	LC	H	3	6	8	3	5	8	8	7	3	4	6	4	7	4
	GC	I	5	7	3	1	6	7	7	7	4	4	3	2	6	3
38	LC	F	5	4	7	3	4	6	5	6	4	3	7	4	7	7
	GC	G	4	6	5	2	4	4	5	7	5	3	4	3	6	5
39	LC	H	2	2	6	2	5	8	8	3	2	3	3	2	8	4
	GC	I	3	3	3	1	3	3	3	6	3	7	6	2	6	5
* Controller selected two values.																

Table B1: West Runway Plan – ATC Post-Run Rating Results

West Runway Plan - Level 1 - Feedback	
Q16	GC: Lack of visibility at Term. A on east side cannot see a/c pushed back except on ASDE. This is true for west side directly below tower.
	GC: Can't see much of Terminal A except on BRITE.
Q17	GC: Gate numbering should be uniform in all terminals. Suggest all even numbers on one side; all odd number on the other side, sequentially from one end to the other.
	LC: The airport should be set up for intersection departures "E". This would enable the controller to use both runways for departures and keep arrivals crossing the inboard runway. Intersection "Mike" could be used for rwy 36R dept. to expedite arrivals using Q to cross from twy A.

Table B2: West Runway Plan, Level 1 – ATC Post-Run Feedback

West Runway Plan – Level X - Feedback	
Q16	LC: Crossing 36R
	GC: Runway crossings
	LC: Crossing traffic. This is dangerous.
	GC: Tower should be higher at least 200', better angle to look down & scan.
	LC: Arrival aircraft on the departure runway. Level of heavy jet departures.
	GC: Runway crossings were the most problem. It slows the whole operation down.
	LC: Need a sooner high speed turn off. Land hold short for crossing need help!
	GC: One a/c turned the wrong way and when I tried to change the line of moving a/c, it didn't work. As long as you can keep two way traffic in B & C, it worked pretty good.
Q17	LC: It would be nice to see taxiway A go around the end of the inboard runway so that arrival aircraft would not have to cross the departure runway.

Table B3: West Runway Plan, Level X – ATC Post-Run Feedback

West Runway Plan – Level Y - Feedback	
Q16	LC: The potential for runway incursions is much higher when you have large volume of aircraft holding short of an active runway.
	GC: The departures outbound at spots 7 & 8 should be, by rights, sequenced behind departures in the queue who have been waiting longer. In this configuration, it is best done by holding the queue at 'L' taxiway and filtering the departures in. But this means the spot 7 departures have to wait for the appropriate spot in line. Meanwhile more departures are pushing back behind them. The ramp will soon get congested unless the controller pushes the later departures in front of the earlier ones.
	LC: (Safety) Local Controller has to work his traffic and ground control (Twy A & when exiting) which diverts attention from departures & arrivals. (Congestion) Without taxi access via the outer apron by ATC, aircraft are penalized during a large departure push by having aircraft closer to rwy departure end getting out before the ones waiting much longer.
	GC: Departure queue moves too slow(*ly*) to effectively sequence departures. For example, putting heavies on B & non-heavies on C, or splitting SIDS.
	LC: 1) Holding aircraft short in order to get more departures out. 2) Higher risk for runway incursions 3) Hammering ground control when you bring 8 to 10 aircraft across at once to the ramp.
	GC: In cases where several transmissions are given in sequence, the pilot-operators seemed to "get behind". A few more fingers may be needed.
	LC: Again this configuration splits tower controller's attention from working the rwy and providing ground control on twys A & B and at intersections. Workload is too much at times of heavy traffic. Not safe as I had a go-around because too much of my attention went to working ground.
	GC: Congestion when aircraft is flushed across the runway. Conflict between arrival aircraft and departure aircraft.
Q17	LC: Pilots normally call tower at outer marker which would add more accuracy to transmission counts & complexity as this would be using up time that the controller now uses to issue instructions. Don't know the logistics but perhaps one more pilot assisting.
	GC: No.
	GC: It would be helpful to know the priorities. Did you want aircraft out in the order of the priorities as much as possible or most efficient use of taxiway w/o regard to priorities?
	LC: Much more complex operation.
	LC: Perhaps more pilots or input operators to help make heavy traffic move smoothly
	GC: What is the priority?

Table B4: West Runway Plan, Level Y – ATC Post-Run Feedback

Post-Run Survey Results – Midfield Terminal Plan

Midfield Terminal Plan – Question Ratings																
Run	**Pos.**	**ID**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**	**Q15**
Level 1																
3	LC	C	8	8	8	8	8	8	8	8	1	8	1	8	8	8
	GC	A	7	7	7	7	6	7	6	6	5	8	3	7	7	7
4	LC	A	8	8	8	8	7	6	5	5	6	8	3	8	7	7
	GC	C	8	8	8	8	8	8	8	8	1	8	1	8	6	8
8	LC	B	8	8	8	8	1	8	7	6	6	8	1	8	8	8
	GC	A	8	8	8	8	8	8	8	8	1	8	1	8	7	8
9	LC	C	8	8	8	8	1	6	7	6	6	8	1	8	8	8
	GC	A	8	8	8	7	6	7	6	7	6	8	3	8	7	7
13	LC	C	8	8	8	8	8	8	8	5	5	8	1	8	8	8
	GC	B	8	8	7	8	4	4	4	6	6	8	1	8	8	7
14	LC	B	8	8	8	8	4	6	6	6	5	8	1	8	8	7
	GC	A	8	8	8	8	6	6	6	7	3	8	2	7	8	7
15	LC	A	7	7	8	8	2	5	3	7	2	7	3	8	8	8
	GC	B	8	8	8	8	3	6	6	4	6	8	1	7	8	7
18	LC	B	8	8	8	8	3	7	7	6	6	8	1	8	8	7
	GC	C	8	8	8	8	8	8	8	8	6	8	2	8	8	8
19	LC	C	7	8	8	8	8	8	8	8	7	7	2	8	8	8
	GC	B	7	7	7	6	3	7	7	6	6	8	1	8	8	6
Level X																
20	LCE	E	8	8	8	8	8	8	8	8	8	6	3	8	8	8
	GCE	D	6	6	6	8	6	6	6	5	5	6	5	7	4	6
	LCW	A	7	7	8	7	4	6	7	7	3	7	3	8	8	8
	GCW	C	8	8	n/a	8	8	8	8	8	2	8	1	8	8	8
24	LCE	C	n/a	8	8	8	8	8	8	8	3	6	3	8	8	8
	GCE	A	7	8	7	7	7	6	6	7	3	6	5	8	8	6
	LCW	B	8	8		8	7	8	8	8	8	8	4	8	8	8
	GCW	E	8	8	n/a	8	8	8	8	8	8	8	1	8	8	8
25	LCE	A	7	7	7	8	7	6	6	6	5	7	4	8	8	8
	GCE	D	5	5	6	7		5	6	6	5	3	4	5	6	6
	LCW	B	8	8	n/a	7	7	7	7	7	7	7	5	7	8	8
	GCW	C	8	8	n/a	8	8	8	8	8	1	8	1	8	8	8
27	LCE	D		7	6	8	7	7	7	7	6	6	5	7	6	6
	GCE	A	7	6	7	8	6	6	5	7	5	7	5	8	8	7
	LCW	B	7	7	n/a	7	7	7	7	7	5	3	4	7	7,8*	8
	GCW	C	8	8	n/a	8	8	8	8	8	1	8	1	8	8	8
29	LCE	A		7	6	8	7	7	7	7	6	6	5	7	6	6
	GCE	D	7	6	7	8	6	6	5	7	5	7	5	8	8	7
	LCW	B	7	7	n/a	7	7	7	7	7	5	3	4	7	7,8*	8
	GCW	C	8	8	n/a	8	8	8	8	8	1	8	1	8	8	8

Table B5: Midfield Terminal Plan, Level 1 & X – ATC Post-Run Rating Results

Midfield Terminal Plan – Question Ratings																
Run	**Pos.**	**ID**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**	**Q15**
Level Y																
33	LCE	G	8	8	7	8	7	7	7	7	7	6	2	7	8	7
	GCE	F	8	8	7	8	7	7	7	7	8	7	3	8	8	7
	LCW	I	8	8	n/a	8	8	8	8	8	8	8	1	8	8	8
	GCW	H	8	8	n/a	8	5	2	2	8	5	8	1	3	8	5
35	LCE	I	7	8	7	7	7	7	7	7	7	6	3	7	8	7
	GCE	G	8	8	7	8	7	6	7	7	7	7	4	7	8	7
	LCW	H	8	8	n/a	8	5	5	5	7	5	8	1	5	8	5
	GCW	F	8	8	n/a	8	8	8	8	8	8	8	4	8	8	7
36	LCE	H	6	7	7	8	5	6	6	8	7	6	5	5	8	5
	GCE	I	7	7	7	8	7	7	7	7	7	7	3	7	8	7
	LCW	F	8	8	n/a	8	8	8	8	8	8	8	5	8	8	8
	GCW	G	8	8	8	8	8	7	8	7	8	8	1	7	8	8
37	LCE	F	8	8	8	8	8	8	8	8	8	7	5	8	8	8
	GCE	H	8	8	8	8	5	5	5	8	5	5	6	7	8	5
	LCW	G	7	8	7	8	7	7	7	7	6	8	1	7	8	7
	GCW	I	8	8	n/a	7	7	7	7	7	7	8	1	8	8	8
* Controller selected two values.																

Table B6: Midfield Terminal Plan, Level Y – ATC Post-Run Rating Results

Midfield Terminal Plan – Level 1 - Feedback	
Q16	LC: I think the arrivals are turning off the runway too soon. All except one (MYT868) turned off at A4. More a/c should roll to A3.
	LC: Scanning of the departure runway was more difficult due to the restrictions of position location more than the airport layout itself.
	GC: The scan issue would not be a factor with 2 LC's & 2 GC's. It's only an issue with 1 LC and 1 GC.
	LC: Scanning is a problem with 2 controllers.
	GC: If the tower was higher (200'). It would be easier to scan the runways.
Q17	LC: I really like the mid operation.
	GC: The size of the ramp area is absolutely great. Movement on the ramp is excellent due to the space that is available. Arrivals never interfere with departures & vice versa.

Table B7: Midfield Terminal Plan, Level 1 – ATC Post-Run Feedback

Midfield Terminal Plan – Level X - Feedback	
Q16	LCE: An earlier high speed turn off for smaller aircraft.
	GCE: Couple of aircraft stalled and/or (*there were*) radio issues.
	LCE: Arrivals on the departure runway. Large number of heavy jets.
	GCE: Leader lines were conflicting in the departure queue.
	GCW: Arrivals could allow some departures to be run in this configuration.
	LCE: Pilot was unable to execute a missed approach. Separation of aircraft was maintained, however.
	LCW: Tower should be higher, would help the scanning. If there were no arrivals to 18L, it would be very easy to run the traffic with only one dept. route out of the valley. It would be more difficult to run visual dept's.
	LCE: I believe the taxiways and runway configuration is setup perfectly to affect an expeditious and safe flow of traffic.
Q17	GCW: Safety – Big Plus.
	GCE: Problem worked well.
	LCW: With the airport you could use 36L for 5-8 departures taking the load off 36R with the amount of "Heavy" Jet ops that are going to be numerous dept. holes.
	LCW: Still could use some departures.
	GCW: Should take a look at raising the tower to 200 ft. It will enhance the visibility.

Table B8: Midfield Terminal Plan, Level X – ATC Post-Run Feedback

Midfield Terminal Plan – Level Y - Feedback	
Q16	LCE: No critical problems noted.
	GCE: Didn't encounter any problems.
	LCW: Too slow – seems a waste. But probably in the real environment, LC will probably be busier because of adjustments on final and runway management.
	GCW: Under utilized airport although not much since the arrivals are lined up with minimal spacing. West controller workload almost nonexistent
	LCE: If an aircraft develops a problem on "W" past "M", it will be difficult to remove him from the queue.
	GCE: At the beginning of the problem, departures are lined up at V and W. Until LC moves the line up, it's difficult to feed in more departures at spot 22.
	LCW: With dedicated arrival runway, there is no need for ground control.
	LCE: Large departure push only using one runway could send some to west runway. Unable to use Ramp to help stage departure near departure end N/P taxiways.
	GCE: Due to the departure queue, workload is increased from aircraft coming out at Papa. It should be easier to work if the Papa aircraft would come to Mike on the ramp. Also departure GC will more efficient with an assist.
	GCW: Arrival side ground – nothing critical.
	LCE: Did not see any problems. In fact, this is possibly the easiest configuration.
	GCE: At first, (*this problem*) tends to be a bit overwhelming where a ground assist or metering position would help. Towards the end (*of the week, this problem*) became very slow for ground. Mostly hunting for strips at first.
	GCW: Very light traffic – lots of extra capacity.
Q17	LCE: None.
	GCE: Much easier operation with widely spaced runways.
	LCW: None.
	GCW: Still thinking.
	LCE: None.
	GCE: None.
	LCE: Again controller reaching out to clear aircraft to land happens but to be more real, pilots should call at the outer marker, if not cleared to land before that.
	GCE: What are the priorities? Priorities or efficiency or balance?
	GCW: None.
	GCW: None.

Table B9: Midfield Terminal Plan, Level Y – ATC Post-Run Feedback

Airfield Comparison Survey Results

Level 1 – Questions Ratings																		
Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**	**Q15**	**Q16**	**Q20**	**Q21**	**Q22**	**Q23**
N	W	N	W	W	N	N	C	N	W	W	W	N	N	W	W	7	7	6	7
W	W	W	W	C	C	W	C	C	C	W	C	W	W	W	W	6	6	6	6
W	W	N	W	W	W	N	N	C	C	W	W	N	N	W	W	6	7	6	6
W = Widely-Spaced or Midfield Terminal Plan C = Closely-Spaced or West Runway Plan N = No difference																			

Table B10: Level 1 - Airfield Comparison Results, ATC Rating Results

Level 1 – Controllers' Feedback	
Q17	Widely Spaced – No Runway Crossing
	At this level of traffic, the closely spaced would be preferable. The closely space rwys give controllers more flexibility to mix arrivals & dept's when it gets busy. Using intersection dept's and both rwys for dept's when arrivals are slow. It's easier to scan when everything is in front of you. It is difficult to scan when part of the airport is at your back.
	Widely Spaced. Less chance for runway incursions. Able to move traffic faster & more efficiently.
Q18	Add intersection dept's for 18R/36L & 18L/36R on all airfield designs. Use the yellow line on the edge (ghost route) to move a/c around.
	Both runways need to be the same length, i.e. 15000 ft. This gives the controller much flexibility should a runway be closed or there becomes a need for simultaneous arrivals or departures.
Q19	I think the baseline traffic volume was too light. It could have been double what we did to have situations to work out of.
	Uniform gate numberings. High speed exits need to be directed to the proper entry point at the ramp with little or no other movement (like side stepping).
Q24	Traffic levels were too low & simplistic but realism was very good.

Table B11: Level 1 – Airfield Comparison Results, ATC Feedback

Level X – Questions Ratings																		
Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**	**Q15**	**Q16**	**Q20**	**Q21**	**Q22**	**Q23**
W	W	W	W	W	W	W	C	W	W	W	W	W	W	W	W	6	5	7	6
W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	8	6	7	6
W	W	W	W	W	W	N	W	W	W	W	W	W	W	W	W	7	6	6	6
W	W	W	W	W	N	W	W	W	W	W	W	W	W	W	W	6	7	7	7
W	W	N	W	N		N	N	W	W	W	W	N	N	W	W	6	6	6	6
W = Widely-Spaced or Midfield Terminal Plan C = Closely-Spaced or West Runway Plan N = No difference																			

Table B12: Level X – Airfield Comparison Survey, ATC Rating Results

Level X – Controllers' Feedback	
Q17	Widely spaced, especially at Level X, safer, much easier to manage traffic flow with the restricted departure area. The departures must be managed closely "splitting SID's, etc.
	Widely spaced is by far the best!! It is safer; easier to work; more effective."
	Widely spaced – no mix of crossing runways. Faster tax for arrivals to the gate. Slim chance of runway incursions. Easy to handle large volume of aircraft.
	Widely spaced – safety & controller workload.
	Runway incursions seem to be totally eliminated on the widely spaced layout. No airplanes are required to cross an active runway. Traffic congestion to and from the terminals is minimal in widely spaced layout. Because arrivals & departures are predominately separated once beyond the ramp."
Q18	Make the edge of the ramp (Ghost Route) a preferred taxi route to the gates. Departure spots would have to be pushed back away from C some. The East/West taxi lanes should be one way, all the way from C-V and from V-C. There were several head on operations by a/c on the correct route during widely space runs. Taxiway F between B→C should be wider to allow a/c transitions from B to C or C to B (closely spaced). The tower needs to be taller.
	Need more high speed turnoff. Bigger hold pads to hold EDCT with respect to delay, etc. Flow restrictions, de-ice inspections (if needed) may not need for your location."
	Both runways should be the same length. This gives better flexibility. Would like to see the tower at 200 feet. Some departures could be run from the arrival runway on the widely spaced option.
	Both runways should be 15,000'.
Q19	Staffing in tower would make a difference as would traffic volume for the lighter volume. The closely spaced plan would be better as the traffic builds. The widely spaced would be preferable.
	Well prepared scenarios. Compiled data should validate the widely spaced layout."
Q24	Better software for pilots. Use gradual turns on ground so a/c don't look jerky when turning.
	ASDE & RADAR should be next to each other rather than separated by the com station. Pilots need better software to move aircraft more realistically.
	When discussing movements with the pilots, it was determined they had very cumbersome keyboard entries to move a/c as expeditiously as we could have liked on occasion.

Table B13: Level X – Airfield Comparison Survey, ATC Feedback

Questions Ratings – Level Y																		
Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**	**Q15**	**Q16**	**Q20**	**Q21**	**Q22**	**Q23**
W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	3	7	7	4
W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	5	7	6	3
W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	7	7	7	7
W	W	W	W	N	W	N	C	N	W	W	W	W	N	W	W	6	5	7	5
W = Widely-Spaced or Midfield Terminal Plan C = Closely-Spaced or West Runway Plan N = No difference																			

Table B14: Level Y- Airfield Comparison Survey, ATC Rating Results

Controllers' Feedback – Level Y	
Q17	Of the two, I choose the widely because of the safety issues: 1. Local works local not ground. 2. Dedicated departure works occasional arrival. 3. Ground has more time to sequence aircraft. 4. Arrivals get to gates sooner (at least to Ramp) and away from runways, minimal delays. 5. Easier to concentrate on area of responsibility
	Widely spaced is preferable. Workload on LC is too great in the closely spaced and the runway crossings will increase the runway incursions.
	Widely spaced configuration because: 1. Less holding between runways. 2. Less risk of runway incursions. 3. Less frequency congestion.
	Widely spaced because: A. Precludes runway crossings B. Provides more opportunity to sequencing the departure line up ("splitting SIDS"). C. Provides for consistent taxiway, shorter routes from runway to ramp.
Q18	I would let go some ramp space & build two parallels on one side with another runway on the other side of the airport. As is, build taxiway bypass around ends of runways to move aircraft that may break or have flow times. As is, aircraft are stuck in line. Make one more taxiway for west side configure so ground can stage aircraft and move them around for above reasons.
	It could be good to have a bigger apron at the approach end to move aircraft around. (Mechanical problems on EDCT times, etc.) This is for both configurations. It would be good to have a high-speed taxiway as the last taxiway on the landing runways.
	Both alternatives will need "hammered areas" at the departure ends to accommodate aircraft with controller release times as well as other delay issues (no numbers, etc). Closely spaced layout would also benefit from a third taxiway parallel to W and V.
Q19	First time for me (*as a participant at FFC*), so considering the limitations, I think it was real as well as could be. Maybe more pilots to move more aircraft. Have them call inbounds.
	It would be more evident how difficult it is to move aircraft around if there were priorities. Having an assist for LC departure and GC departure positions for wide configuration would be good.
	The local assist and at time ground assist was a great asset.
	No.
Q24	More pilots would make the problem more realistic. Nighttime simulation may show areas of difficult to see because of glaring lights, etc.
	It was unrealistic to have so many departures. In the NAS, we would have had gate hold procedures in place to reduce delays and fuel waste.
	During dense traffic periods the pseudo-pilots have trouble keeping up with too many instructions in a row ("rapid-fire"). Tower controllers, GC in particular, use rapid-fire when multiple conflicts are developing and the timing of each instruction becomes critical.

Table B15: Level Y - Airfield Comparison Survey, ATC Feedback

Appendix C: Averaged ATC Post-Run Survey Results

The following table lists the averaged controllers response for each questions.

	Pos.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q10	Q11	Q12	Q13	Q14	Q15
West Runway Plan, Level 1															
North-Flow	LC	7.25	7	7.5	6.5	5.75	5.75	6.75	7	3.25	8	1.75	6.25	8	7.75
	GC	7.5	7.5	7.5	7.25	4.75	7.5	7.25	6.5	5.25	7.75	1.75	7.25	6.75	7.5
South-Flow	LC	7.25	7	7.5	6.5	6.25	6.75	6.5	7.25	3.5	7.75	2	6.75	8	7.5
	GC	7.25	7.5	7.25	6	4.5	6.5	6.5	7.5	4.5	6	2.25	6	7.75	7.75
Midfield Terminal Plan Level 1															
North-Flow	LC	7.75	7.75	8	8	2.75	6.25	5.5	6	5	7.75	2	8	7.75	7.75
	GC	8	8	8	7.75	6.25	7.25	7	6.75	3.5	8	1.5	7.75	7	7.5
South-Flow	LC	7.75	8	8	8	5.75	7.25	7.25	6.25	5.75	7.75	1.25	8	8	7.5
	GC	7.75	7.75	7.5	7.5	5.25	6.25	6.25	6.75	5.25	8	1.5	7.75	8	7
West Runway Plan, Level X															
North-Flow	LC	2	4	4	2	4.5	6	6	6	3.5	2.5	7.5	3.5	4.5	3.5
	GC	5	6.5	5	5	6	6.5	6.5	6,5	5	5.5	6.5	4.5	7.5	6.5
South-Flow	LC	3	3	3	1	4	4	3	4	5	3	6	1	6	5
	GC	4	6	6	4	6	6	7	7	3	3	7	5	5	7
Midfield Terminal Plan, Level X															
North-Flow	LCE	8	8	8	8	8	8	8	8	5.5	6	3	8	8	8
	GCE	6.5	7	6.5	7.5	6.5	6	6	6	4	6	5	7.5	6	6
	LCW	7.5	7.5	8	7.5	5.5	7	7.5	7.5	5.5	7.5	3.5	8	8	8
	GCW	8	8	n/a	8	8	8	8	8	5.5	7	2	8	8	8
South-Flow	LCE	7	7	6.5	8	7	6.5	6.5	6.5	5.5	6.5	4.5	7.5	7	7
	GCE	6	5.5	6.5	7.5	6	5.5	5.5	6.5	5	5	4.5	6.5	7	6.5
	LCW	7.5	7.5	n/a	7	7	7	7	7	6	5	4.5	7	8	8
	GCW	8	8	n/a	8	8	8	8	8	1	8	1	8	8	8
West Runway Plan – Level Y															
North-Flow	LC	3	6.5	8	4	5.5	7	7.5	7	4.5	4	6	4	6.5	5
	GC	4	6.5	3	1	6	6	6	7	5	3.5	3.5	2.5	5.5	3.5
South-Flow	LC	3.5	3	6.5	2.5	4.5	7	6.5	4.5	3	3	5	3	7.5	5.5
	GC	3.5	4.5	4	1.5	3.5	3.5	4	6.5	4	5	5	2.5	6	5
Midfield Terminal Plan, Level Y															
North-Flow	LCE	7	7.5	7	8	6	6.5	6.5	7.5	7	6	3.5	6	8	6
	GCE	7.5	7.5	7	8	7	7	7	7	7.5	7	3	7.5	8	7
	LCW	8	8	n/a	8	8	8	8	8	8	8	3	8	8	8
	GCW	8	8	8	8	6.5	4.5	5	7.5	6.5	8	1	5	8	6.5
South-Flow	LCE	7.5	8	7.5	7.5	7.5	7.5	7.5	7.5	7.5	6.5	4	7.5	8	7.5
	GCE	8	8	7.5	8	6	5.5	6	7.5	6	6	5	7	8	6
	LCW	7.5	8	7	8	6	6	6	7	5.5	8	1	6	8	6
	GCW	8	8	n/a	7.5	7.5	7.5	7.5	7.5	7.5	8	2.5	8	8	7.5

Table C1: Averaged ATC Post-Run Survey Results

Appendix D: Tower Cab Layout

West Runway Plan

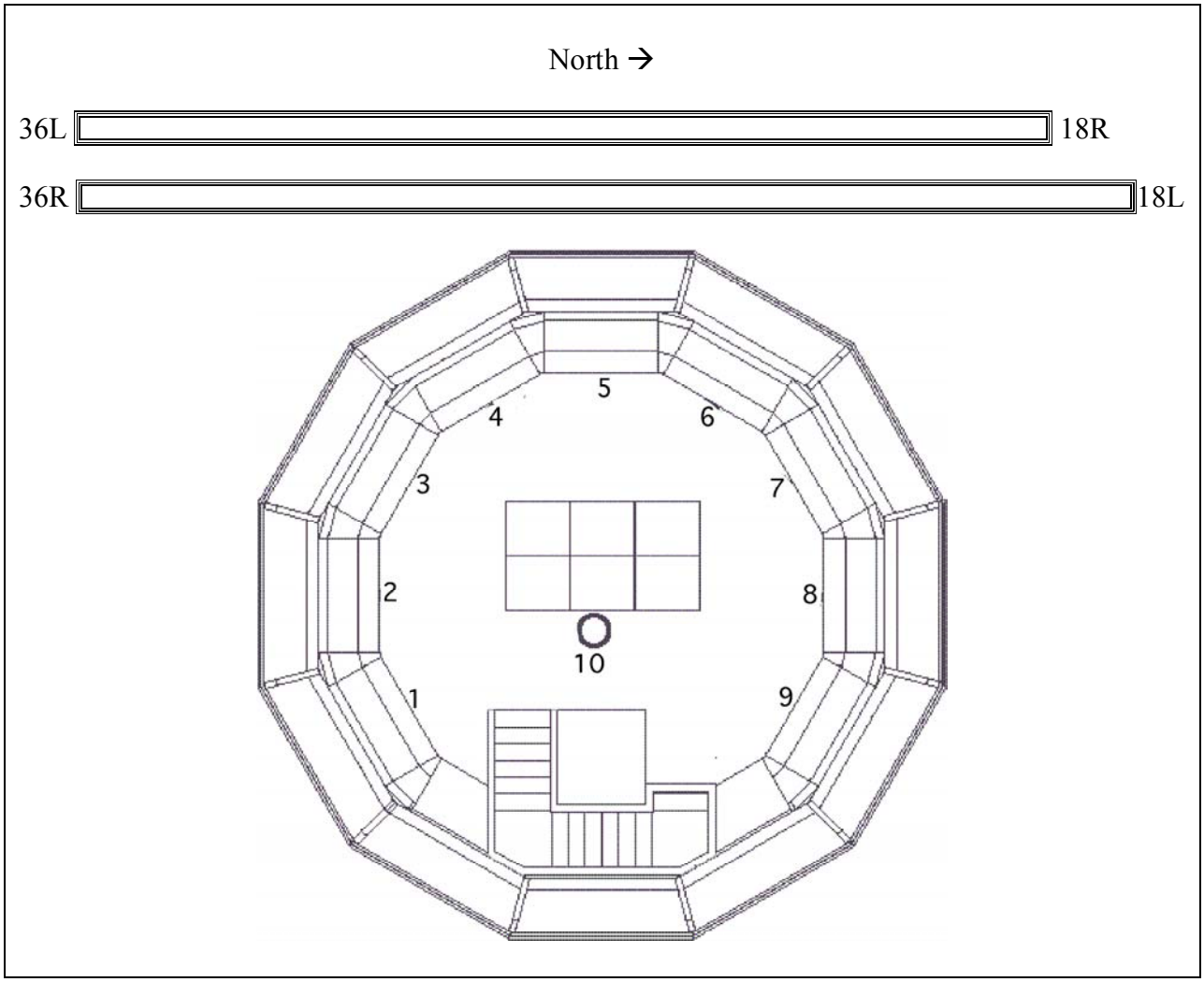

Figure D1: West Runway Plan – Airport and Tower Layout

Tower Station	Controller Position	Radio Frequency
4	Local	117.7
5	Ground	121.2

Table D1: Controller Positions – West Runway Plan, North-Flow, Levels 1, X & Y

Tower Station	Controller Position	Radio Frequency
5	Ground	121.2
6	Local	117.7

Table D2: Controller Positions – West Runway Plan, South-Flow, Levels 1, X & Y

Midfield Terminal Plan

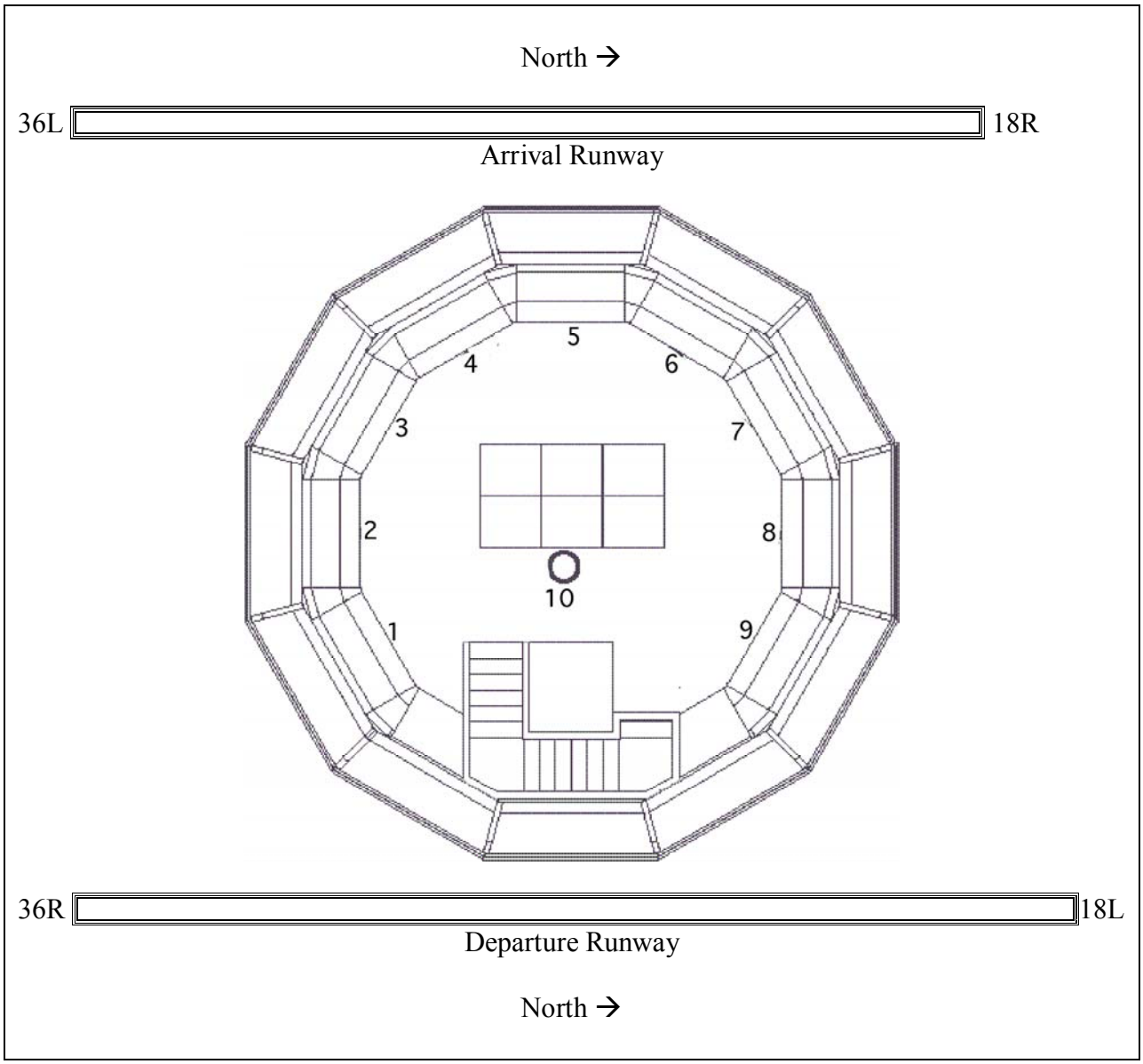

Figure D2: Midfield Terminal Plan – Airport and Tower Layout

Tower Station	Controller Position	Radio Frequency
1	Local	117.7
2	Ground	121.2

Table D3: Controller Positions – Midfield Terminal Plan, North-Flow-Level 1

Tower Station	Controller Position	Radio Frequency
8	Ground	121.2
9	Local	117.7

Table D4: Controller Positions – Midfield Terminal Plan, South-Flow, Level 1

Tower Station	Controller Position	Radio Frequency
1	Local East	118.9
2	Ground East	121.8
4	Local West	117.7
5	Ground West	121.2

Table D5: Controller Positions – Midfield Terminal Plan, North-Flow, Levels X & Y

Tower Station	Controller Position	Radio Frequency
5	Ground West	121.2
6	Local West	117.7
8	Ground East	121.8
9	Local East	118.9

Table D6: Controller Positions – Midfield Terminal Plan, South-Flow, Levels X & Y

Appendix E: Summary of the Digital Audio Communications

In column 2, TX indicates the controller transmission to the sim-pilots and RX indicates the sim-pilots transmission to the controller.

Controller		Total recorded time (mm:ss.d)	Total # of transmissions	Avg. length of transmission	% Airtime
Level 1					
Run 2 – West Runway Plan, North-Flow, Night					
Local	RX	50:14.7	55	2.6	4.7
	TX	50:14.7	55	4.5	8.2
Ground	RX	50:14.7	61	2.5	5.1
	TX	50:14.7	40	2.4	4.5
Run 4 – Midfield Terminal Plan, North-Flow, Night					
Local	RX	45:56.6	65	2.2	5.2
	TX	45:56.6	45	3.4	5.5
Ground	RX	45:56.6	63	2.6	5.9
	TX	45:56.6	28	3.1	3.1
Run 6 – West Runway Plan, North-Flow, Day					
Local	RX	46:05.8	83	2.2	6.6
	TX	46:05.8	75	3.9	10.6
Ground	RX	46:05.8	52	2.4	4.4
	TX	46:05.8	41	2.9	4.2
Run 7 – West Runway Plan, North-Flow, Night					
Local	RX	45:59.7	69	2.5	6.3
	TX	45:59.7	56	3.2	6.6
Ground	RX	45:59.7	52	3.1	5.8
	TX	45:59.7	43	3.2	5.0
Run 8 – Midfield Terminal Plan, North-Flow, Day					
Local	RX	46:10.9	68	2.6	6.3
	TX	46:10.9	63	3.9	8.8
Ground	RX	46:10.9	73	2.5	6.7
	TX	46:10.9	34	3.0	3.6
Run 9 – Midfield Terminal Plan, North-Flow, Night					
Local	RX	45:54.0	51	2.1	4.0
	TX	45:54.0	49	3.8	6.8
Ground	RX	45:54.0	50	2.9	5.4
	TX	45:54.0	24	2.3	2.0
Run 10 – West Runway Plan, North-Flow, Day					
Local	RX	45.55.1	74	2.7	7.2
	TX	45.55.1	72	4.5	11.7
Ground	RX	45.55.1	55	3.2	6.4
	TX	45.55.1	53	1.7	3.2

Controller		Total recorded time (mm:ss.d)	Total # of transmissions	Avg. length of transmission	% Airtime
Run 11 – West Runway Plan, South-Flow, Day					
Local	RX	46:10.9	75	2.5	6.7
	TX	46:10.9	67	3.5	8.5
Ground	RX	46:10.9	60	2.9	6.3
	TX	46:10.9	34	3.0	3.7
Run 12 – West Runway Plan, South-Flow, Night					
Local	RX	46:01.7	62	2.4	5.3
	TX	46:01.7	60	3.1	6.8
Ground	RX	46:01.7	54	2.7	5.3
	TX	46:01.7	25	3.8	3.5
Run 13 – Midfield Terminal Plan, South-Flow, Day					
Local	RX	46:01.7	66	2.4	5.7
	TX	46:01.7	59	3.2	6.8
Ground	RX	46:01.7	74	2.1	5.7
	TX	46:01.7	38	3.1	4.2
Run 14 – Midfield Terminal Plan, South-Flow, Night					
Local	RX	45:47.9	49	2.4	4.4
	TX	45:47.9	50	3.9	7.1
Ground	RX	45:47.9	62	2.2	5.0
	TX	45:47.9	36	2.0	2.6
Run 15 – Midfield Terminal Plan, North-Flow, Day					
Local	RX	46:30.4	67	2.5	5.9
	TX	46:30.4	60	3.2	6.8
Ground	RX	46:30.4	63	2.5	5.6
	TX	46:30.4	35	3.1	3.9
Run 16 – West Runway Plan, South-Flow, Day					
Local	RX	46.07.4	66	2.7	6.5
	TX	46.07.4	60	3.1	6.8
Ground	RX	46.07.4	69	2.9	7.2
	TX	46.07.4	41	4.1	6.0
Run 17 – West Runway Plan, South-Flow Night					
Local	RX	46:09.9	64	2.4	5.6
	TX	46:09.9	61	4.2	9.3
Ground	RX	46:09.9	54	2.6	5.0
	TX	46:09.9	28	2.8	2.9
Run 18 – Midfield Terminal Plan, South-Flow, Day					
Local	RX	46:00.7	62	3.0	6.7
	TX	46:00.7	64	3.8	8.7
Ground	RX	46:00.7	65	2.5	6.0
	TX	46:00.7	36	3.1	4.0

Controller		Total recorded time (mm:ss.d)	Total # of transmissions	Avg. length of transmission	% Airtime
Run 19 – Midfield Terminal Plan, South-Flow, Night					
Local	RX	46:02.8	51	2.4	4.4
	TX	46:02.8	52	3.2	6.1
Ground	RX	46:02.8	56	2.4	4.9
	TX	46:02.8	32	2.7	3.1
Level X					
Run 20 – Midfield Terminal Plan, North-Flow					
Local East	RX	45:51.5	141	1.8	9.1
	TX	45:51.5	153	3.3	18.3
Ground East	RX	45:51.5	112	2.2	9.0
	TX	45:51.5	85	3.0	9.1
Local West	RX	45:51.5	95	3.2	10.9
	TX	45:51.5	67	4.0	9.9
Ground West	RX	45:51.5	66	3.2	7.7
	TX	45:51.5	34	3.8	4.7
Run 22 – West Runway Plan, North-Flow					
Local	RX	45:55.6	252	2.1	19.0
	TX	45:55.6	289	2.9	30.5
Ground	RX	45:55.6	179	2.4	15.9
	TX	45:55.6	121	3.2	14.0
Run 23 – West Runway Plan, North-Flow					
Local	RX	45:59.2	238	2.0	17.2
	TX	45:59.2	265	3.4	33.0
Ground	RX	45:59.2	153	2.5	13.9
	TX	45:59.2	120	4.0	17.5
Run 24 – Midfield Terminal Plan, North-Flow					
Local East	RX	45:44.3	126	2.0	9.0
	TX	45:44.3	136	3.0	14.7
Ground East	RX	45:44.3	114	2.1	8.8
	TX	45:44.3	80	2.8	8.2
Local West	RX	45:44.3	69	3.1	7.8
	TX	45:44.3	96	4.2	14.9
Ground West	RX	45:44.3	67	2.3	5.6
	TX	45:44.3	36	2.8	3.7

Controller		Total recorded time (mm:ss.d)	Total # of transmissions	Avg. length of transmission	% Airtime
Run 25 – Midfield Terminal Plan, South-Flow					
Local East	RX	45.34.1	123	2.2	9.9
	TX	45.34.1	131	2.3	11.0
Ground East	RX	45.34.1	126	2.3	10.8
	TX	45.34.1	96	3.0	10.7
Local West	RX	45.34.1	65	3.7	8.7
	TX	45.34.1	104	3.8	14.5
Ground West	RX	45.34.1	71	2.5	6.5
	TX	45.34.1	37	3.5	4.8
Run 28 – West Runway Plan, South-Flow					
Local	RX	45:53.5	226	2.1	17.2
	TX	45:53.5	234	4.0	33.6
Ground	RX	45:53.5	170	2.3	14.4
	TX	45:53.5	164	3.7	22.1
Run 29 – Midfield Terminal Plan, South-Flow					
Local East	RX	46:14.0	147	2.2	11.9
	TX	46:14.0	160	3.3	18.8
Ground East	RX	46:14.0	105	2.3	8.7
	TX	46:14.0	81	3.0	8.7
Local West	RX	46:14.0	63	3.8	8.7
	TX	46:14.0	72	5.4	13.9
Ground West	RX	46:14.0	78	2.5	7.0
	TX	46:14.0	36	3.3	4.3
Run 30 – West Runway Plan, South-Flow					
Local	RX	46:52.4	219	2.3	18.1
	TX	46:51.9	229	4.3	35.3
Ground	RX	46:51.9	165	2.1	12.2
	TX	46:51.9	149	3.8	20.1
Level Y					
Run 31 – West Runway Plan, North-Flow					
Local	RX	45:45.3	228	2.1	17.7
	TX	45:45.3	265	3.3	32.0
Ground	RX	45:45.3	218	2.6	20.6
	TX	45:45.3	214	2.9	22.5
Run 32 – West Runway, North-Flow					
Local	RX	45.53.0	268	1.9	19.0
	TX	45.53.0	280	3.0	30.5
Ground	RX	45.53.0	213	2.6	20.2
	TX	45.53.0	197	2.3	22.8

Controller		Total recorded time (mm:ss.d)	Total # of transmissions	Avg. length of transmission	% Airtime
Run 33 – Midfield Terminal Plan, North-Flow					
Local East	RX	46.18.6	217	2.0	15.2
	TX	46.18.6	217	2.9	22.7
Ground East	RX	46.18.6	138	2.9	14.2
	TX	46.18.6	130	4.1	19.1
Local West	RX	46.18.6	67	2.0	4.9
	TX	46.18.6	67	4.1	10.0
Ground West	RX	46.18.6	62	3.1	6.9
	TX	46.18.6	31	2.5	2.8
Run 35 – Midfield Terminal Plan, South-flow					
Local East	RX	45.56.6	194	2.0	14.1
	TX	45.56.6	190	3.2	21.9
Ground East	RX	45.56.6	146	2.5	13.2
	TX	45.56.6	102	3.0	11.2
Local West	RX	45.56.6	70	1.5	3.8
	TX	45.56.6	72	3.2	8.4
Ground West	RX	45.56.6	57	2.0	4.1
	TX	45.56.6	39	4.0	5.6
Run 36 – Midfield Terminal, North-Flow					
Local East	RX	46.09.4	193	1.9	13.1
	TX	46.09.4	204	2.7	19.8
Ground East	RX	46.09.4	169	2.5	15.5
	TX	46.09.4	123	4.0	17.8
Local West	RX	46.09.4	77	1.6	4.6
	TX	46.09.4	81	3.0	8.8
Ground West	RX	46.09.4	67	2.2	5.3
	TX	46.09.4	34	2.1	2.6
Run 37 – Midfield Terminal Plan, South-Flow					
Local East	RX	45:53.0	192	2.0	14.2
	TX	45:53.0	195	3.0	21.0
Ground East	RX	45:53.0	160	2.6	15.0
	TX	45:53.0	131	3.0	14.5
Local West	RX	45:53.0	63	1.6	3.7
	TX	45:53.0	60	3.6	7.9
Ground West	RX	45:53.0	65	2.3	5.4
	TX	45:53.0	37	3.0	4.0

Controller		Total recorded time (mm:ss.d)	Total # of transmissions	Avg. length of transmission	% Airtime
Run 38 – West Runway Plan, South-Flow					
Local	RX	45:55.1	249	2.1	18.8
	TX	45:55.1	257	3.3	31.1
Ground	RX	45:55.1	219	2.3	18.4
	TX	45:55.1	208	3.1	23.3
Run 39 –West Runway Plan, South-Flow					
Local	RX	45:57.1	224	2.0	16.3
	TX	45:57.1	230	3.2	26.9
Ground	RX	45:57.1	202	2.6	19.3
	TX	45:57.1	174	3.8	24.1

Table E1: Summary of the Digital Audio Communications

Appendix F: Airport Traffic Flow Maps

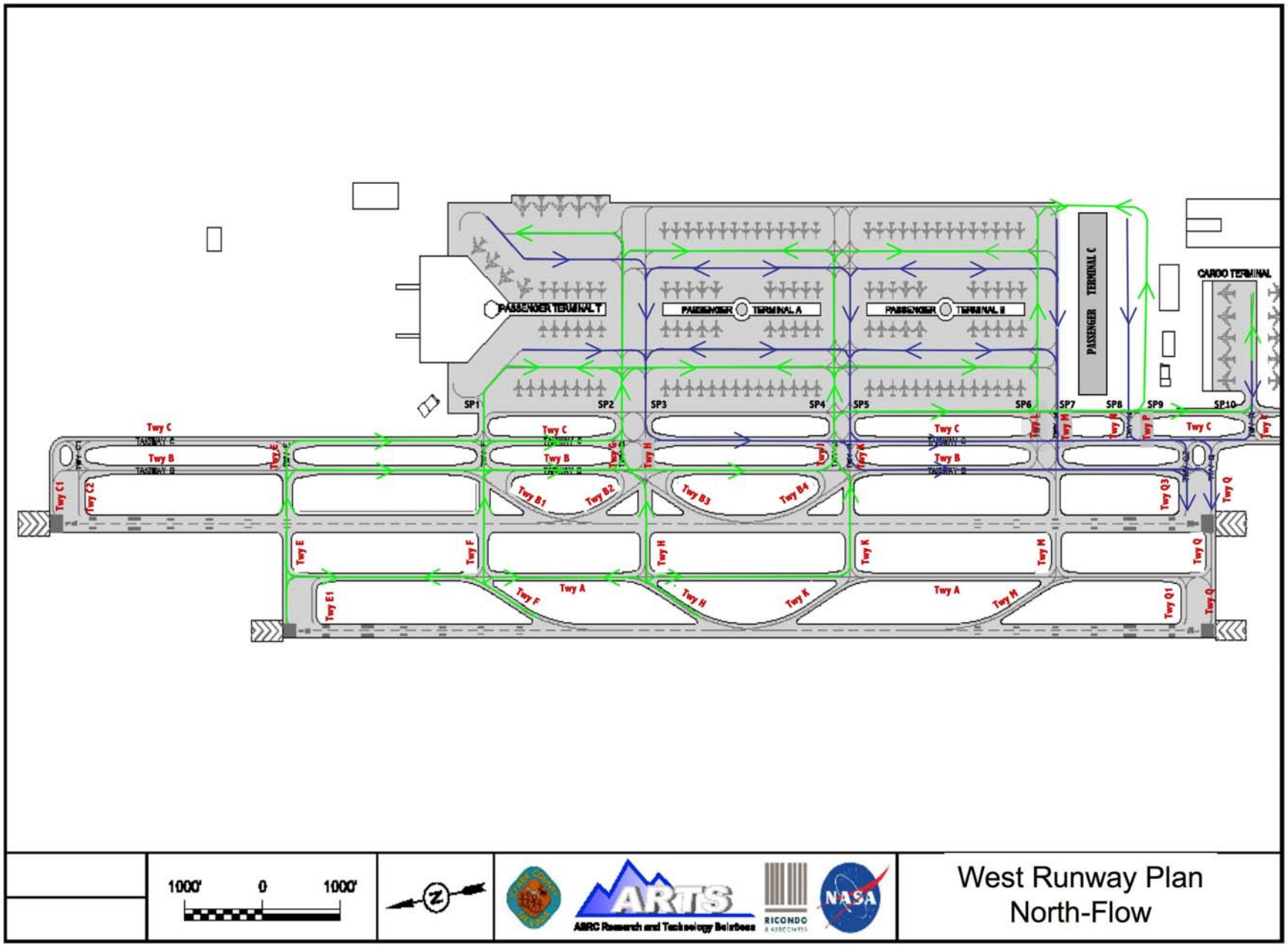

Figure F1: Taxiway Diagram - West Runway Plan, North-Flow

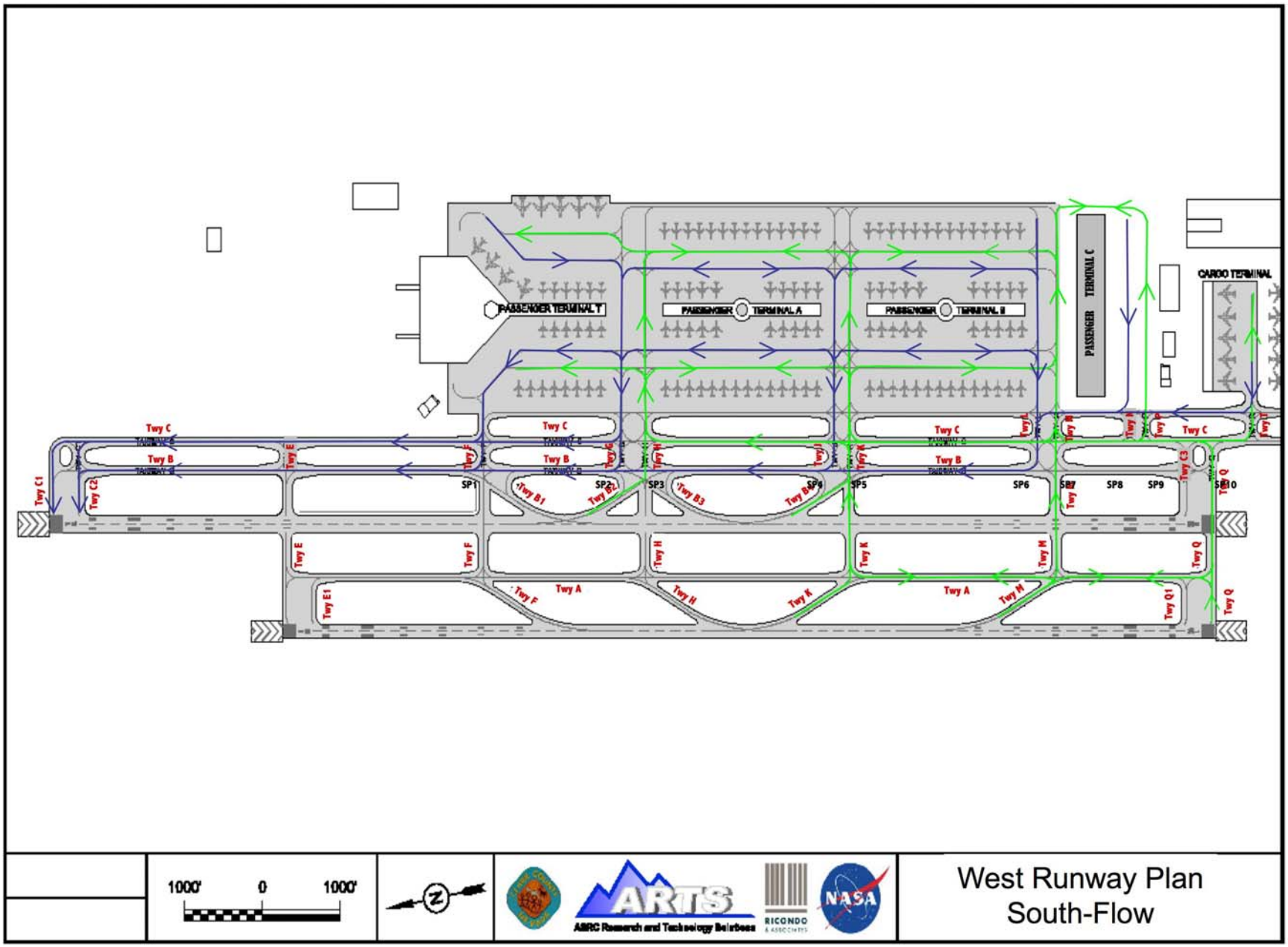

Figure F2: Taxiway Diagram - West Runway Plan, South-Flow

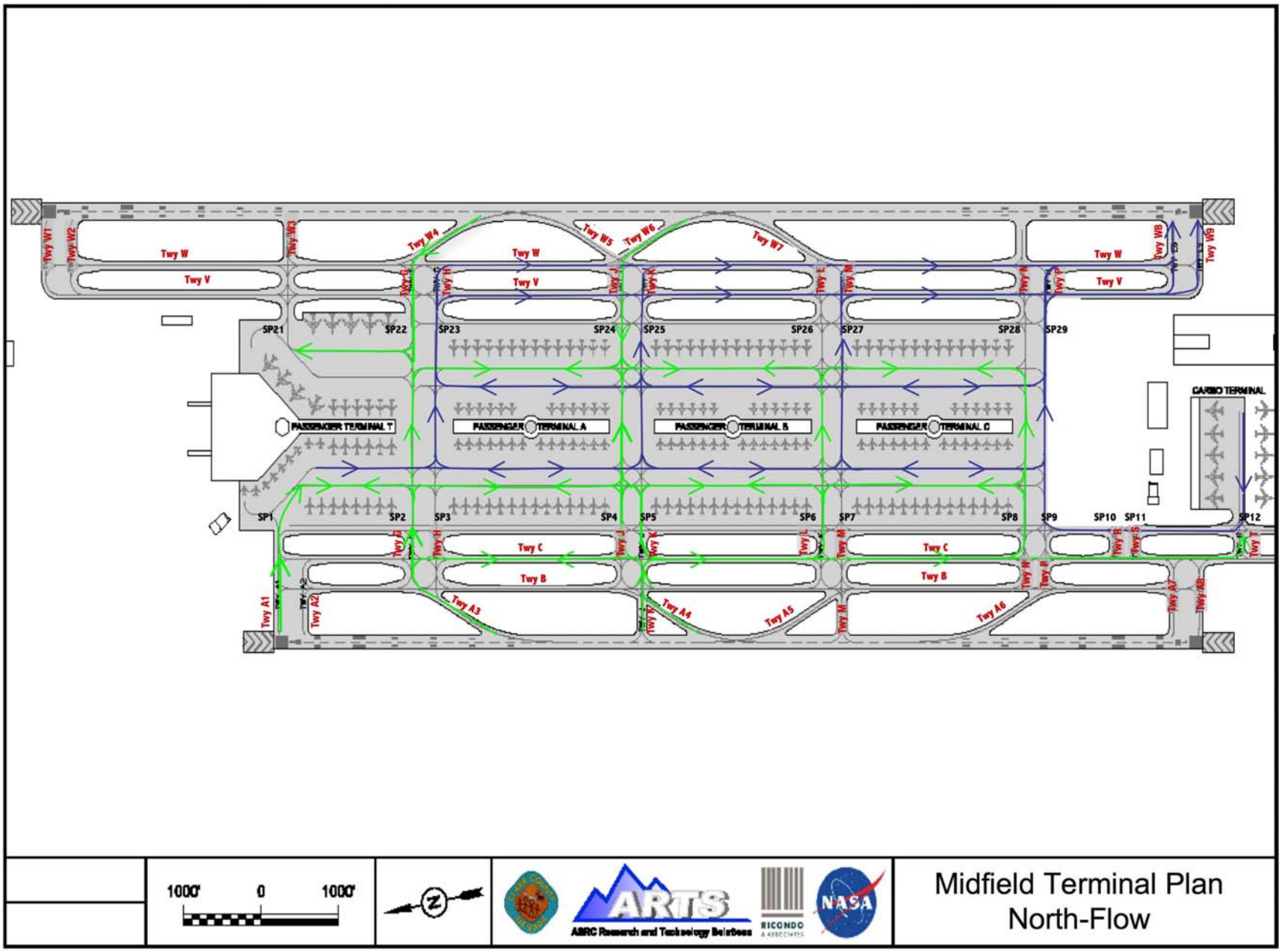

Figure F3: Taxiway Diagram - Midfield Terminal Plan, North-Flow

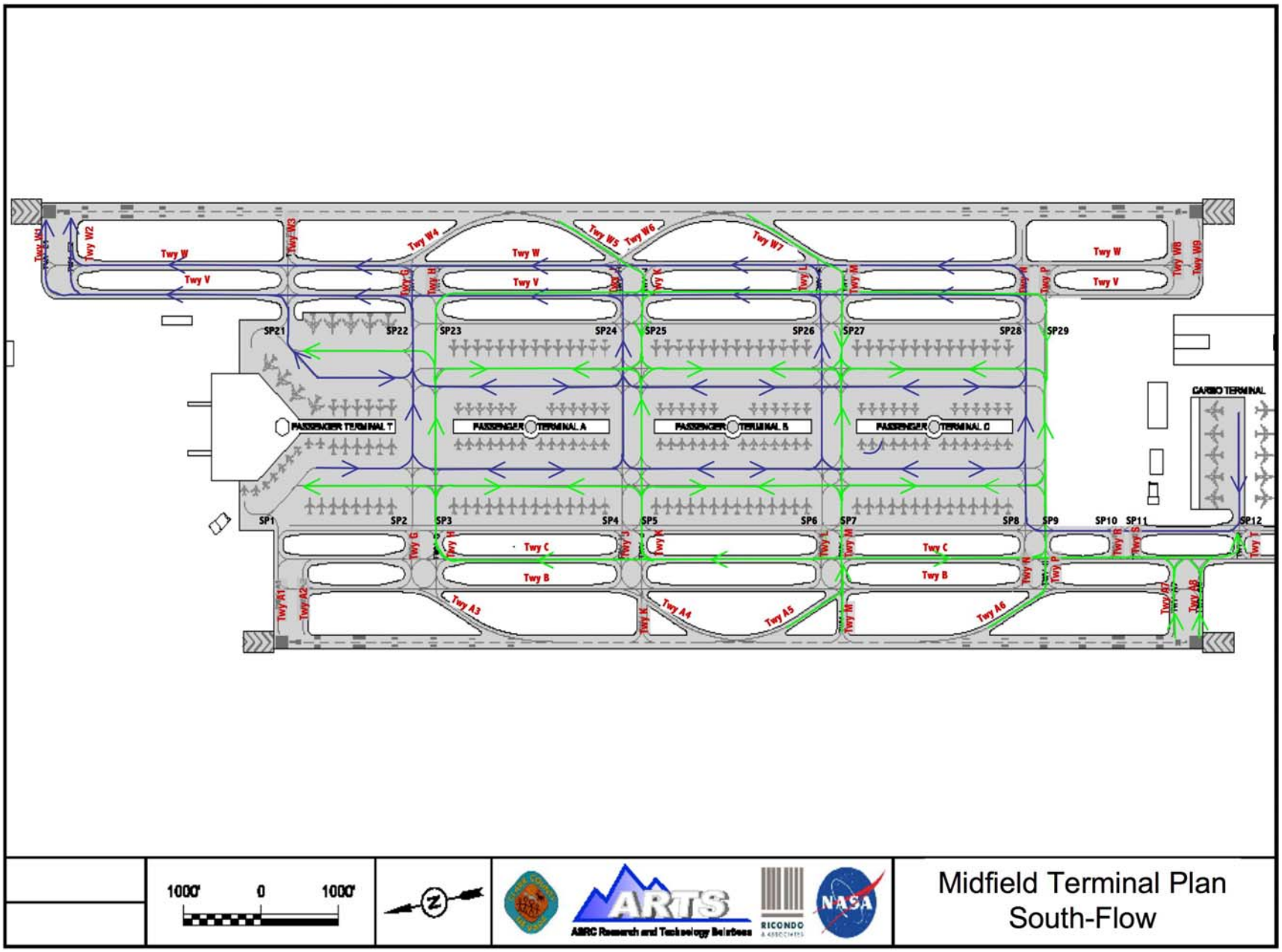

Figure F4: Taxiway Diagram - Midfield Terminal Plan, South-Flow